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ACOUSTIC MEASUREMENTS OF F-4E AIRCRAFT OPERATING IN HUSH HOUSE,--ETC(U)
SEP 81 V R MILLER, G A PLZAK, J M CHINN
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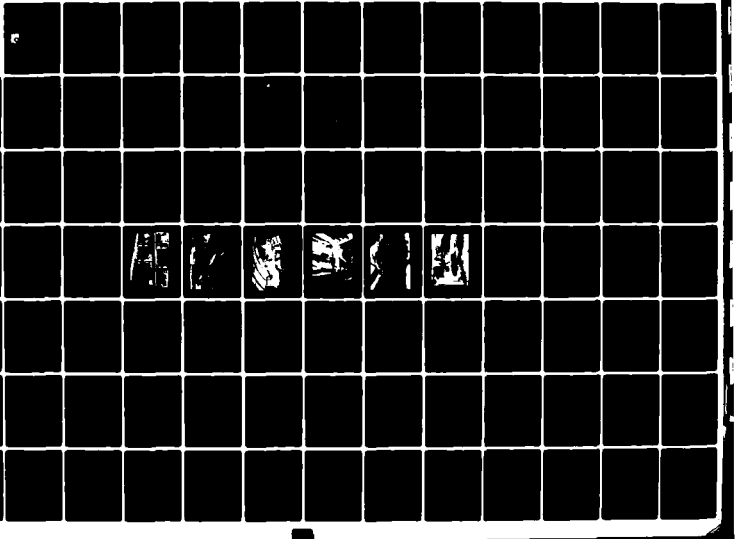

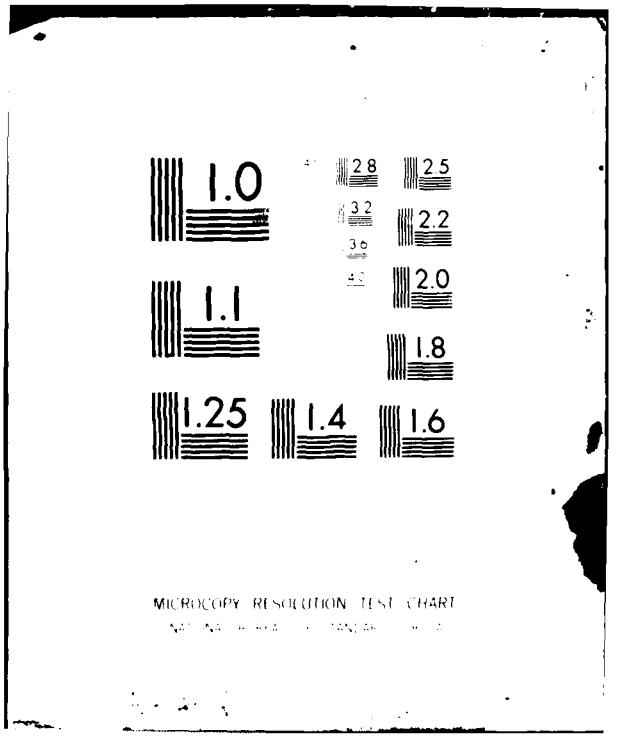
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Acoustic Measurements of F-4E Aircraft Operating in Hush House, NSN 4920-02-070-2721

V. R. Miller
G. A. Plzak
J. M. Chinn

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September 1981

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STRUCTURAL INTEGRITY BRANCH
STRUCTURES & DYNAMICS DIVISION
FLIGHT DYNAMICS LABORATORY
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

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This technical report has been reviewed and is approved for publication.

VINCENT R. MILLER
Project Engineer

HOWARD F. WOLFE
Technical Manager
Acoustics and Sonic Fatigue Group

FOR THE COMMANDER:

FRANK D. ADAMS, Actg Chief
Structural Integrity Branch

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Noise Suppression	Acoustics

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)* The primary purpose of this test program was to measure the acoustic environment in the hush house facility located at Kelly Air Force Base, Texas, during operation of the F-4E aircraft to ensure that aircraft structural acoustic design limits were not exceeded. The acoustic measurements showed that sonic fatigue problems are anticipated with the F-4E aircraft aft fuselage structure during operation in the hush house. The measured acoustic levels were less than those measured in an F-4E aircraft water-cooled hush house at Hill AFB in the lower frequencies, but were increased over that measured during ground run-up on some areas of the aircraft. It was

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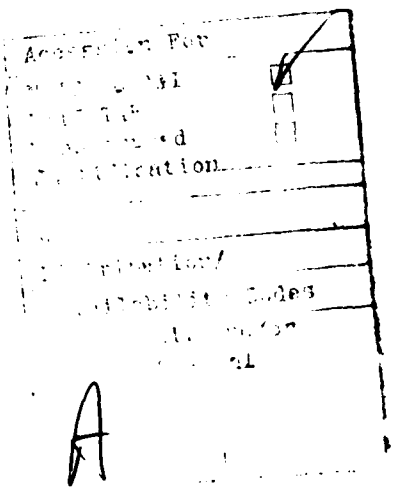
20. recommended that the acoustic loads measured in this program should be specified in the structural design criteria for aircraft which will be subjected to hush house operation or defining requirements for associated equipment. Recommendations were also made to increase the fatigue life of the aft fuselage.

FOREWORD

This effort was performed by the combined efforts of the Structural Integrity and Structural Vibrations Branches, Structures and Dynamics Division, Flight Dynamics Laboratory, Air Force Wright Aeronautical Laboratories, Wright-Patterson AFB, Ohio. This effort was initiated under JON AFLC8102, Program Element 921A, and performed in support of the first article hush house testing program at Kelly AFB, Texas. This program was accomplished to assure contract compliance with respect to noise levels. The work was requested by Ogden ALC, Aircraft Systems Management Division, Directorate of Material Management (Ref. 1) and authorized by Project Order Number MMS-81-035. Mr. D. Lowder (Ogden ALC/MMSRW) was the focal point for this activity. Mr. G. E. Sherwood was the point of contact at Kelly AFB.

The work was performed by Mr. V. R. Miller of the Structural Integrity Branch and Mr. G. A. Plzak and Ms. J. M. Chinn of the Structural Vibrations Branch from May 1981 to September 1981. The authors wish to extend their appreciation to Messrs. M. A. Hart and L. P. Vaughn who assisted with the data acquisition and reduction. Special acknowledgement is due Mmes. J. Tope and M. Arnold for careful typing of the manuscript.

The manuscript was released by the authors in September 1981 as a technical memorandum. This technical memorandum has been reviewed and approved.



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I INTRODUCTION

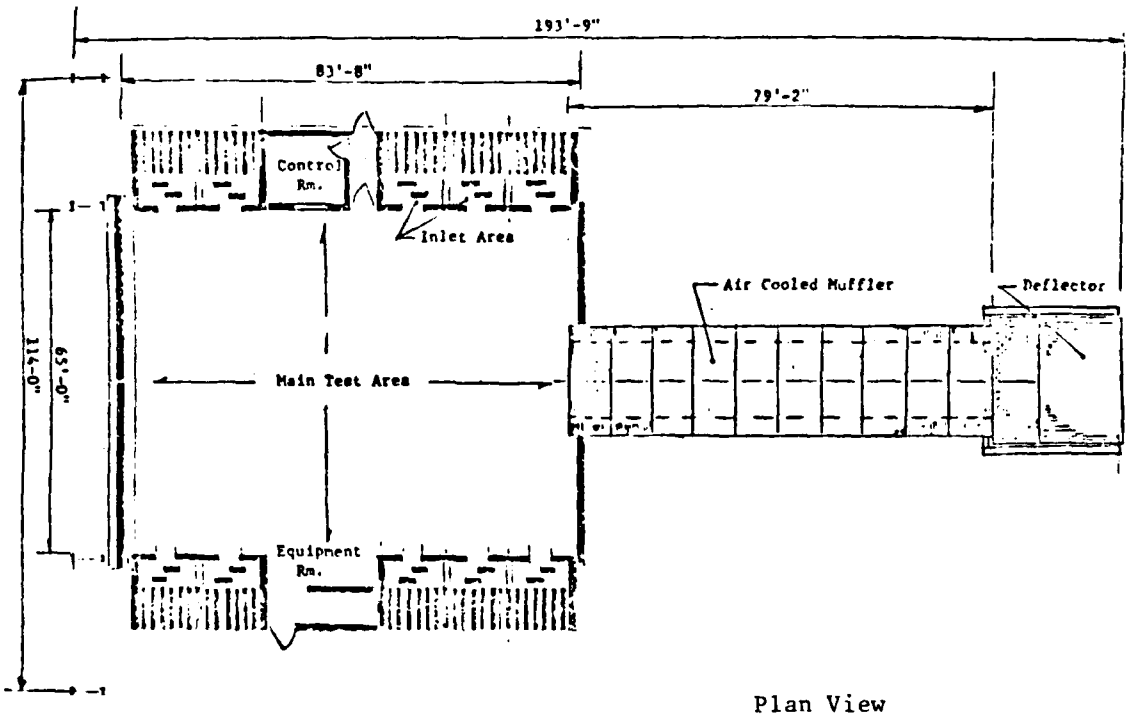
An Aero-Systems Engineering (ASE) hush house, NSN 4920-01-070-2721, was constructed at Kelly AFB, Texas. This hush house is an air cooled noise suppressor system (NSS) which completely encloses installed and uninstalled engines for environmental control purposes during ground run-up. The NSS is compatible with all types of USAF fighter aircraft. Enclosing an aircraft or engine in such a manner can increase the sound pressure levels on the aircraft structure. Increasing the levels can decrease the fatigue life of the aircraft and compromise its structural integrity if acoustic design limits are exceeded. Ogden ALC requested (Ref. 1) the Structures and Dynamics Division of the Flight Dynamics Laboratory to perform a test program to measure the acoustic environment with the F-4E aircraft operating in the ASE hush house. The primary purpose of this effort was to ensure that the acoustic environment within the hush house did not exceed structural design limits and to identify potential problems with the F-4E aircraft structure. The secondary purpose was to measure the sound pressure levels at the top of the hush house deflector, maintenance positions, and near field and compare with other measured data and noise criteria.

A brief description of the hush house is contained in Section II. Section III of this report describes the test, data acquisition, and data reduction procedures used during this program. A discussion of the results is included in Section IV. The conclusions determined from the program are given in Section V with recommendations shown in Section VI. Appendix A shows photographs taken at the test site to document microphone locations, aircraft orientation, etc. Data reduced from the measurements are included in Appendix B.

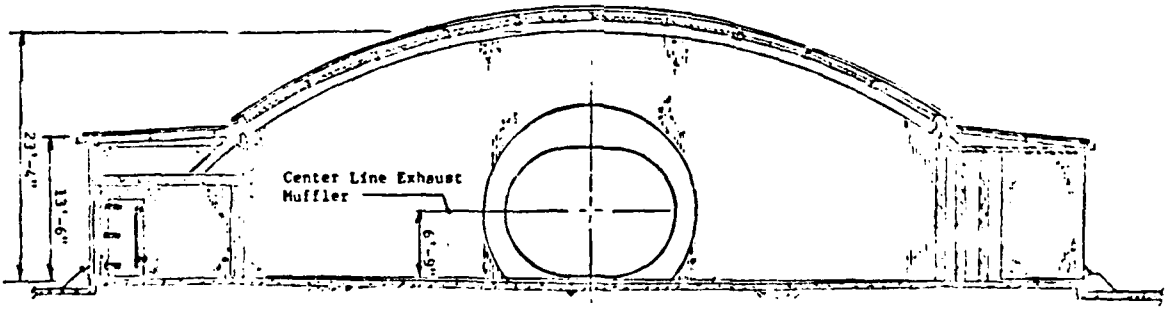
II. DESCRIPTION OF HUSH HOUSE

The hush house which was used during this program is shown in Figure 1. This structure consists of a sound-absorbent hangar with dimensions of approximately 84 by 65 feet (25.6 by 19.8 meters). The surfaces of the hangar were covered with approximately 10,500 square feet (975.5 m^2) of absorbing panels, 4 inches (10.2 cm) thick with a 20 gauge (0.093 cm) perforated face sheet, (304 stainless steel) 16% open area, and filled with a 4.8 lb/ft^3 (76.9 kg/m^3) thermal, fiber-type fill. The fiberglas was wrapped in a fiberglas cloth. The hangar fully encloses both engines and aircraft during ground run-up. The hush house is suitable for testing aircraft of any size and configuration which are geometrically compatible. The aircraft are restrained by tail hooks, wheel chocks, and/or conventional steel cable tiedowns during engine run-up. This hush house is also air-cooled which eliminates the needs for a water spray system in the muffler. Water sprays has a deleterious effect on air quality and acoustic absorptive treatments.

The inlet area allows large air flows and low air velocity past the engine under test. The intake system has a bird screen. Downstream of the bird screen are sound-absorbent baffles arranged as a labyrinth. The engine exhausts into a muffler. Large volumes of air are pumped through the intake system, over the aircraft, and into the muffler to cool the engine exhaust. The muffler is made in sections, each of which consists of several chambers. The inner shell is made of perforated and corrugated 321 stainless steel with 4.50 lb/ft^3 (72.1 kg/m^3) of Basalt wool fill, 4 inches (10.2 cm) thick, around the shell. The exhaust gases leaving the muffler are directed vertically by a deflector.



Plan View



Front Elevation

FIGURE 1 Layout of Hush House

III. TEST, DATA ACQUISITION, AND DATA REDUCTION PROCEDURES

The measurements were conducted at Kelly AFB, Texas, on 10 June 1981, with the F-4E aircraft (S/N 74661) operating in the hanger area of the hush house. The F-4E is an all weather, supersonic, fighter-bomber aircraft powered by two J79-GE-17 turbojet engines (lett S/N 458237, right S/N 458277) which are the major source of ground run-up noise.

The different test runs performed are identified in Table 1. The tests were made with the hangar doors closed. All data were recorded once the engines had stabilized. Table 2 lists the surface meterological condidtions during data acquisition.

The basic transducers used during the test program were located as shown in Figures 2 and 3 and Table 3. The test instrumentation consisted of 25 Gulton Industries Model MVA2100 5/8 inch (1.6 cm) microphones. The microphones were surface-mounted on the aircraft structure and located at the edge of panels to minimize vibration input to the microphones. They were positioned two inches (5.1 cm) from the surface in question with the microphone diaphragms pointed toward the surface. The microphones located around the aircraft were approximately 5 feet (1.5 m) above the floor.

The test procedures which were used were as follows:

(1) Install the F-4E in the hush house hangar area and locate microphones.

(2) Calibrate all data recording instrumentation.

(3) Record ambients prior to test runs.

(4) Operate engines for 20-25 seconds at each of the conditions shown in Table 1.

(5) Edit and review data tapes for quality.

(6) Repeat any test condition shown to be deficient from step (5).

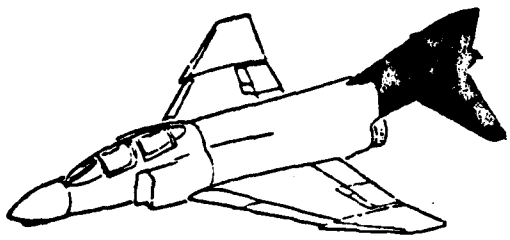
The Flight Dynamics Laboatory's mobile data acquisition van

TABLE 1. SUMMARY OF TEST RUNS FOR F-4E AIRCRAFT

Record Number	Engine Power Settings	
	Left (Port)	Right (Starboard)
20	Ambient	Ambient
21	Military	Idle
22	Idle	Military
23	Max. A/B	Idle
24	Idle	Max. A/B
25	Snap	Idle

TABLE 2. METEOROLOGY

Temperature	34°C/94°F
Bar. Pressure	73.6 cm.Hg /28.995 in. Hg.
Rel. Humidity	51%
Wind	
- Speed	11.1 Km /hr/6 Knots
- Direction	160 deg.



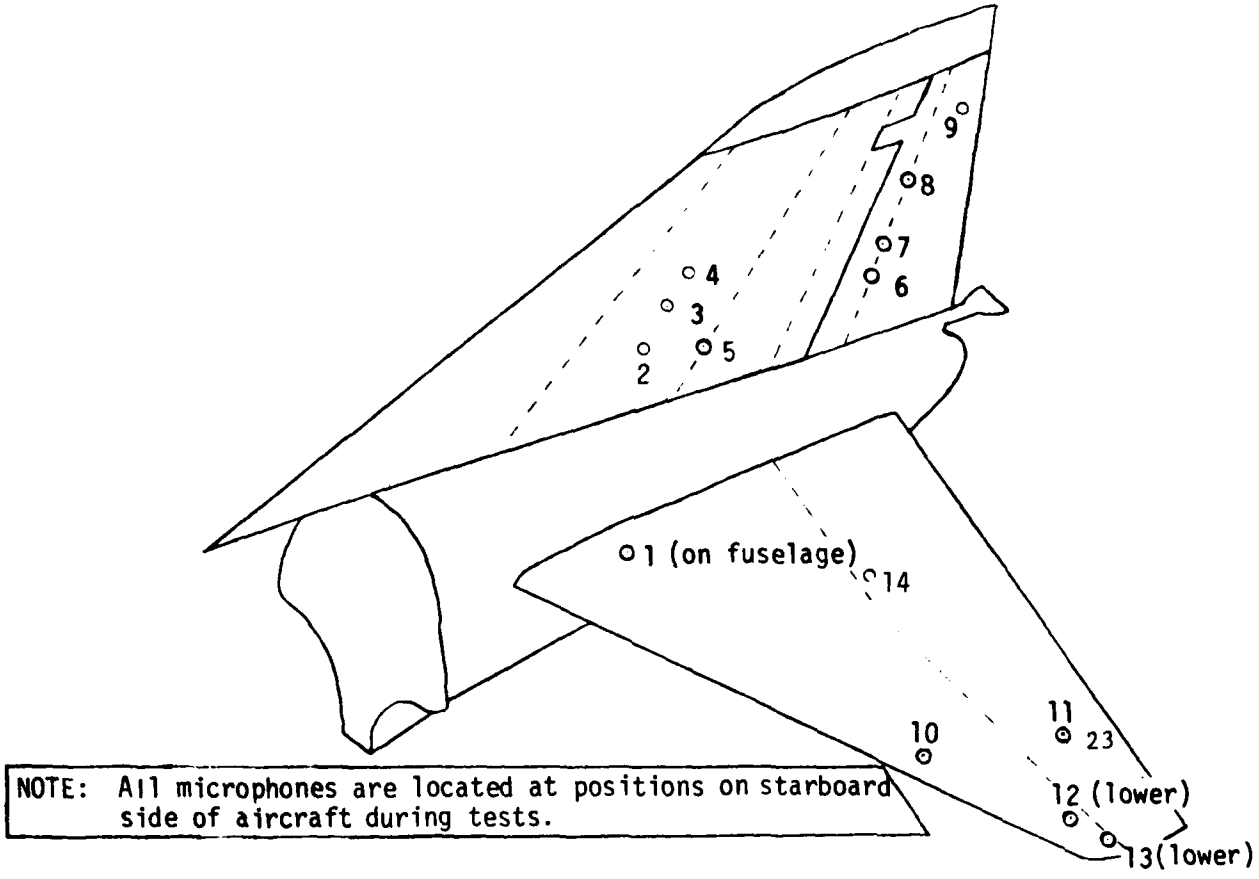


FIGURE 2 Location of Microphones 1-14 and 23 on F-4E Aircraft

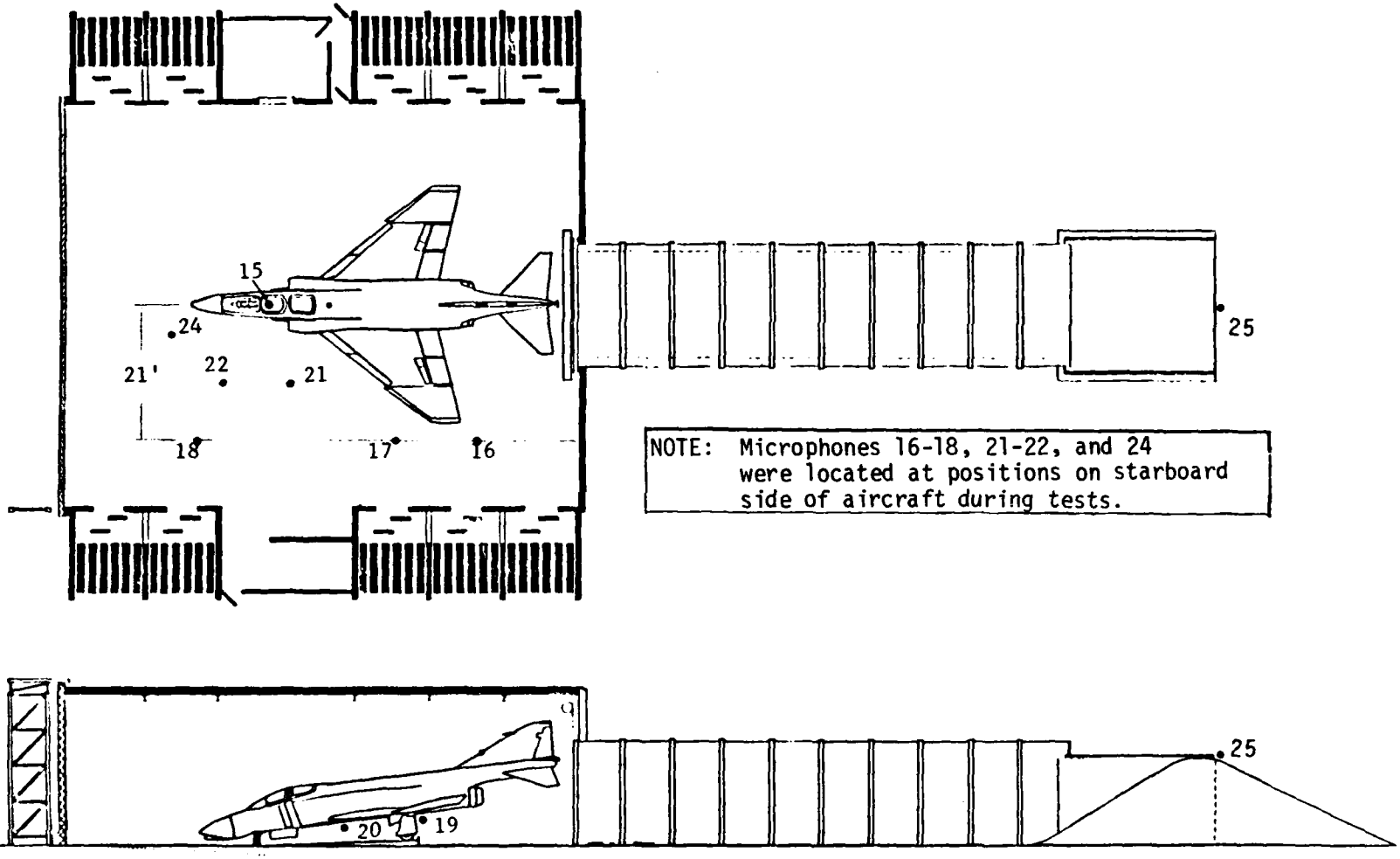


FIGURE 3 Location of Microphones 15-22 and 24-25 Near F-4E Aircraft

TABLE 3. INSTRUMENTATION LOCATIONS

Microphone	Location
1	Fuselage under stabilator
2	Vertical tail, starboard
3	Vertical tail, starboard
4	Vertical tail, starboard
5	Vertical tail, starboard
6	Rudder, starboard side, upper surface
7	Rudder, starboard side, upper surface
8	Rudder, starboard side, upper surface
9	Rudder, starboard side, upper surface
10	Stabilator, upper surface, starboard side
11	Stabilator, upper surface, starboard side
12	Stabilator, lower surface, starboard side
13	Stabilator, lower surface starboard
14	Stabilator, upper surface starboard
15	Cockpit, closed
16	Near-field maintenance position
17	Near-field maintenance position
18	Near-field maintenance position
19	Leak check
20	Bay check
21	Observer
22	Observer
23	Stabilator, upper surface, starboard side
24	Observer
25	Top of Hush House Deflector

contained the signal conditioning electronics and tape transports used for this test program. A block diagram of the instrumentation is shown in Figure 4. Landlines carry the data signal from each microphone to the van. The signal conditioning equipment is capable of producing either attenuation or amplification in 10 dB steps over the range -10 dB to +60 dB. The tape recorders used were Honeywell Model 96 frequency modulation (FM) systems. A time code was produced by a Systron-Donner 8350 time code generator and recorded on one channel of both magnetic tape recorder/reproducers.

The microphones were calibrated by means of a Bruel and Kjaer Type 4220 pistonphone. The magnetic tapes which recorded the data from the tests were played back in the laboratory at Wright-Patterson AFB on the Honeywell 96 record/reproduce system. All analyses were obtained using a General Radio 1921/1926 one-third octave band analyzer interfaced with an ITI 4900 A/D system. All analyses were processed by a Raytheon 704 computer interfaced with a Gould 4800 high speed plotter. Figure 5 shows a block diagram of the overall data reduction process.

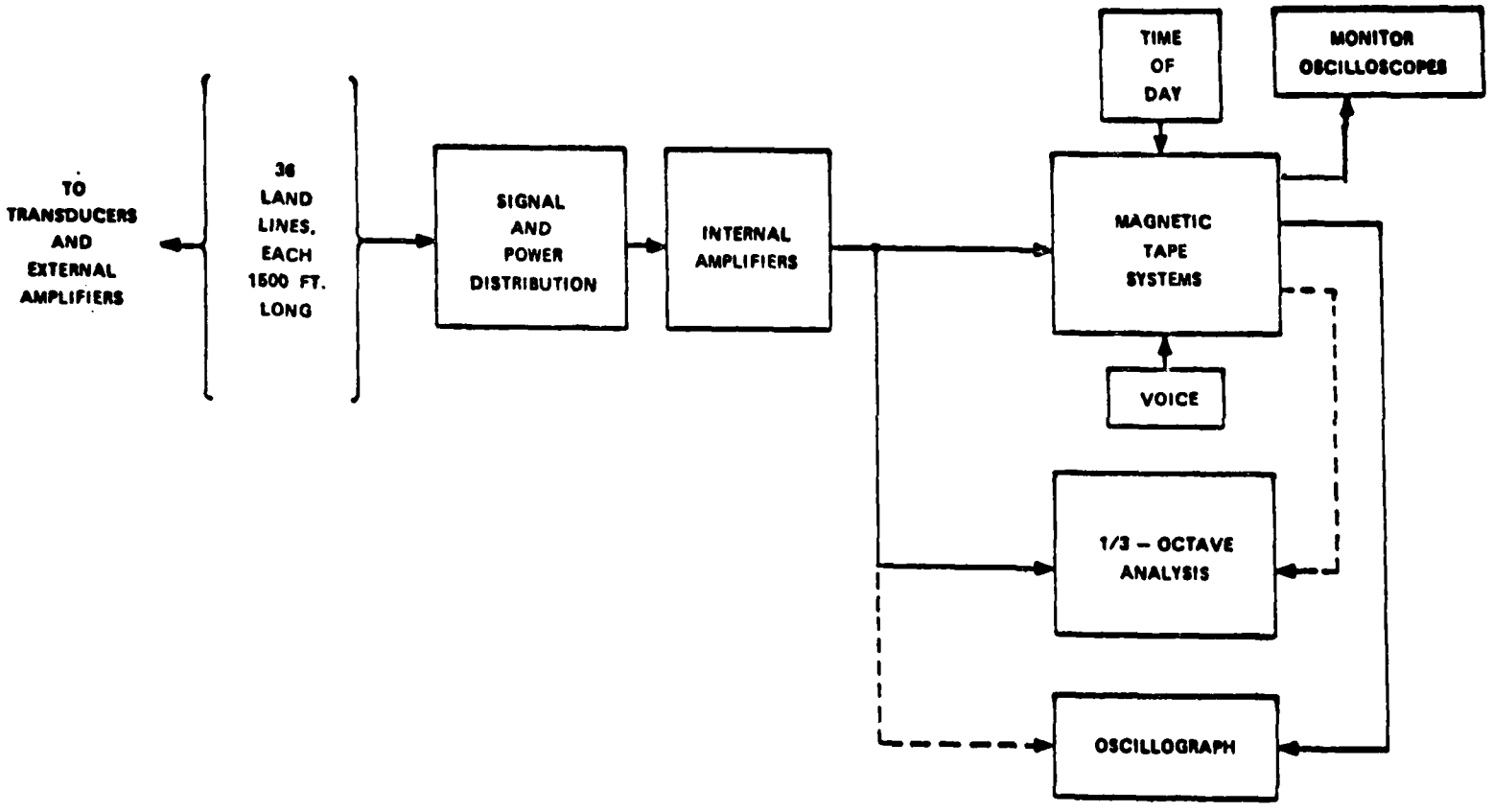


FIGURE 4 Schematic of Data Acquisition System

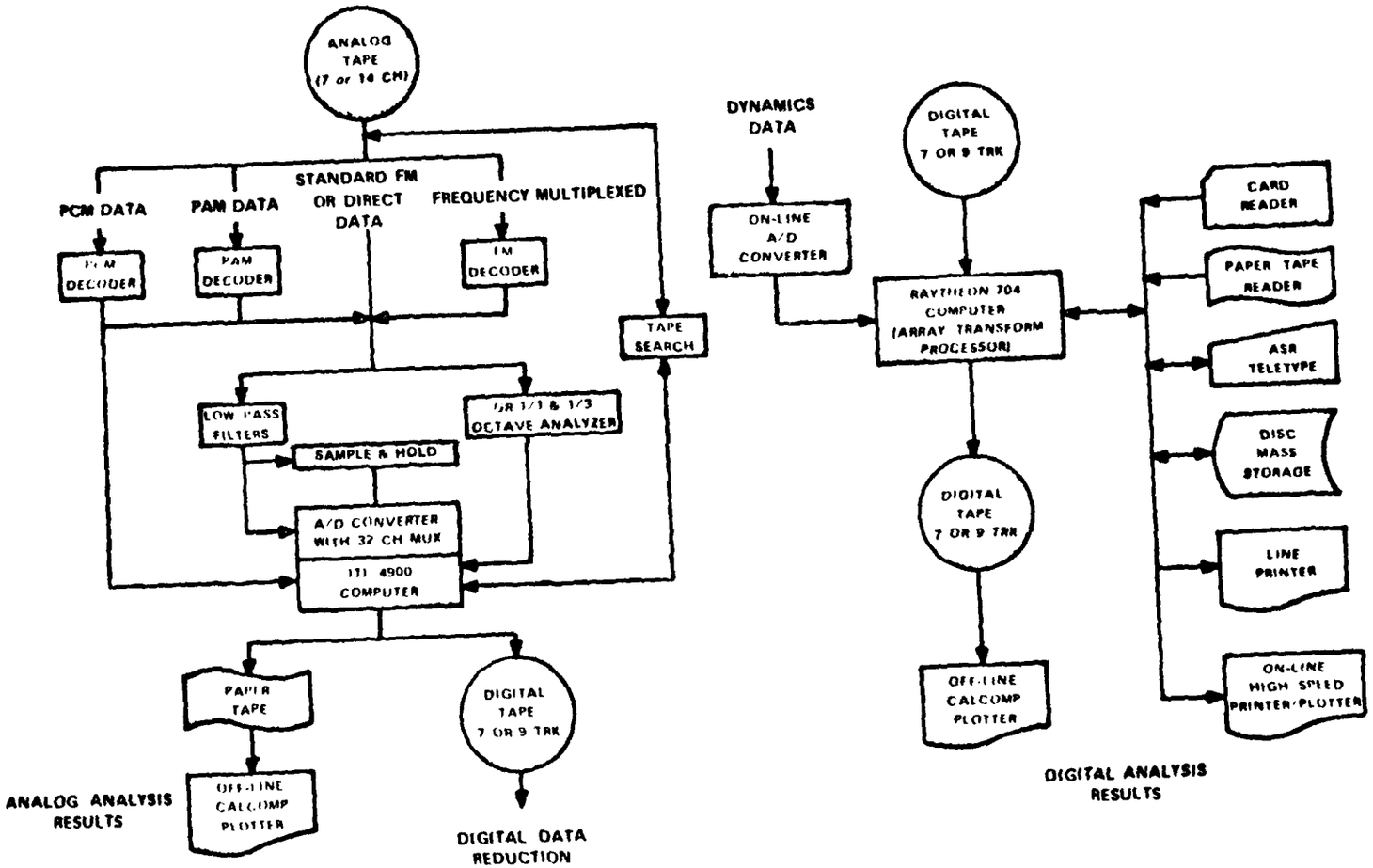


FIGURE 5 Data Reduction Process Diagram

IV. DISCUSSION OF RESULTS

A. Sound Pressure Level Near Aircraft Skin

The sound pressure levels which should not be exceeded for the microphones near the aircraft skin are reported in a McDonnell Aircraft Company study (Ref. 2) and shown on Table 4. These sound pressure levels limits for the F-4E aft fuselage and empennage panels were calculated by first determining panel physical properties. After calculating the panel fundamental mode frequency and establishing a stress concentration factor, the root mean square (RMS) dynamic stress level was determined from random S-N curves given in Reference 3. The structural design levels were calculated from the stress level and then were reduced by 3.5 dB to establish the recommended level. Levels much greater than the structural design levels shown in Table 4 could cause sonic fatigue problems with the aircraft structure. The spectrum levels measured during maximum afterburner (A/B) for microphones 1-13 are plotted in Figure 6 along with the allowable levels from Table 4. The reader should note that the recommended and structural levels as plotted are based on 1 hertz bandwidth while the measured data are plotted as 1.27 hertz bandwidth. The difference resulting from bandwidth change is quite small (approximately 1 dB) and is considered negligible in this analysis. This figure shows that the recommended level is exceeded at microphone locations 1, 7, 9, and 11. The measured sound pressure levels are below the structural design levels at all locations except microphone 1, which is located on the aft fuselage. The maximum measured spectrum level for this microphone was 123 dB which is 5 dB greater than the structural level. At a fundamental frequency of 221 hertz, the

TABLE 4. SOUND PRESSURE LEVEL LIMITS FOR F-4E AFT FUSELAGE AND EMPENNAGE PANELS

Microphone	Allowable Spectrum Level dB (re 0.00002 Pascal)	
	Recommended Level	Structural Design Level
1	123.5	127
2	120	123.5
3	120	123.5
4	120	123.5
5	121	124.5
6	122.5	126
7	121	124.5
8	123	126.5
9	124.5	128
10	132.5	136
11	125.5	129
12	135	138.5
13	134	137.5

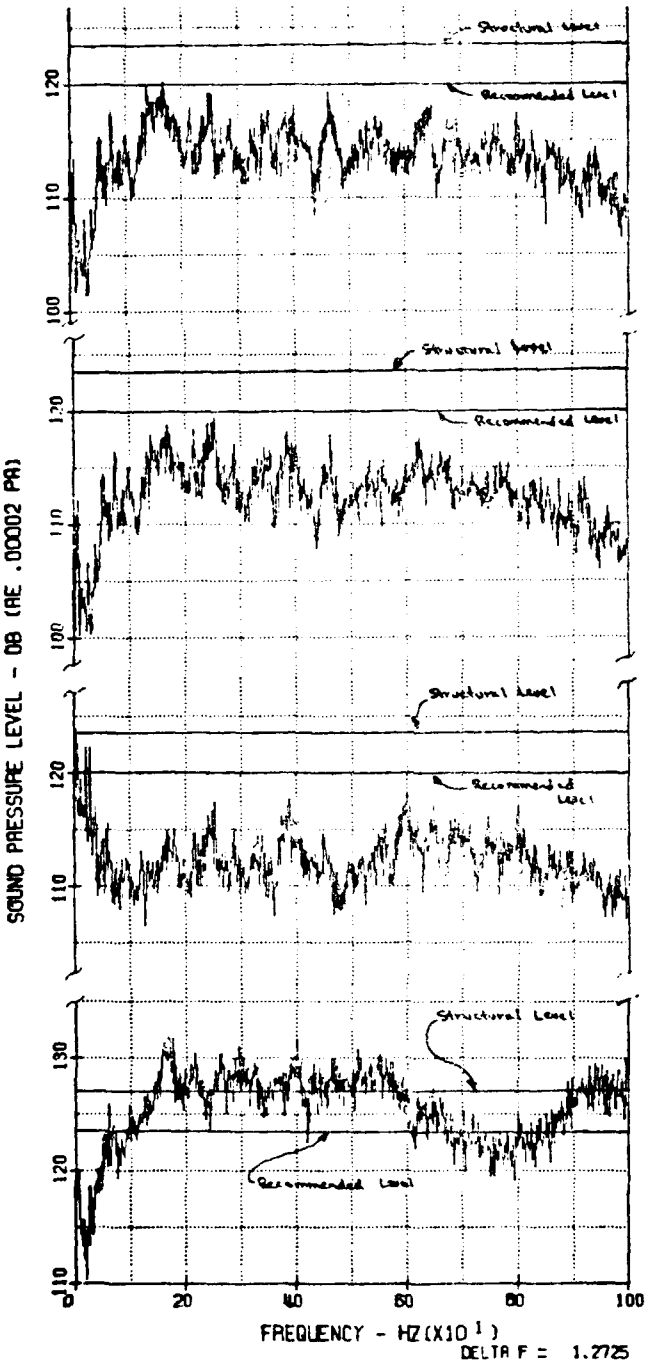


Figure 6 Comparison of Sound Pressure Levels Measured During Maximum Afterburner (Record Number 24) and Allowable Noise Levels on F-4E Aircraft Structure

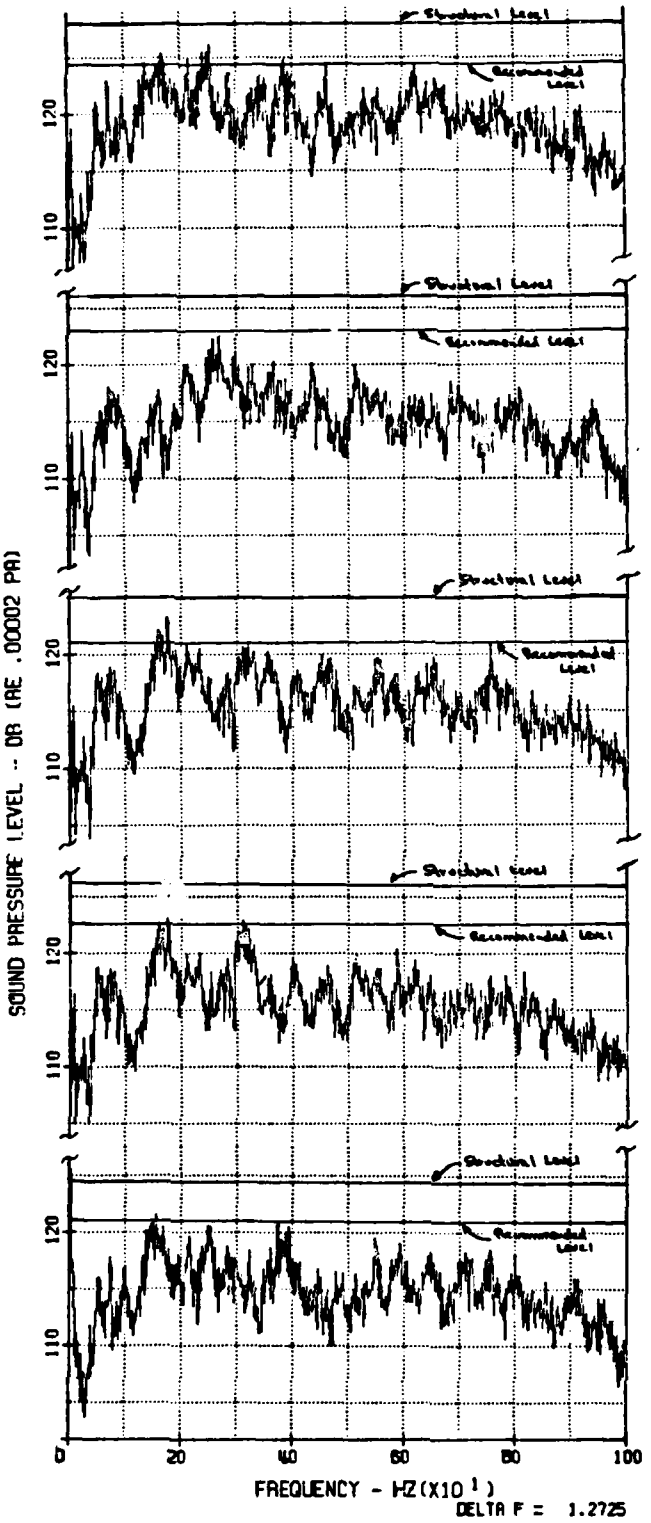


Figure 6 (cont'd) Comparison of Sound Pressure Levels Measured During Maximum Afterburner (Record Number 24) and Allowable Noise Levels on F-4E Aircraft Structure

Microphone Location

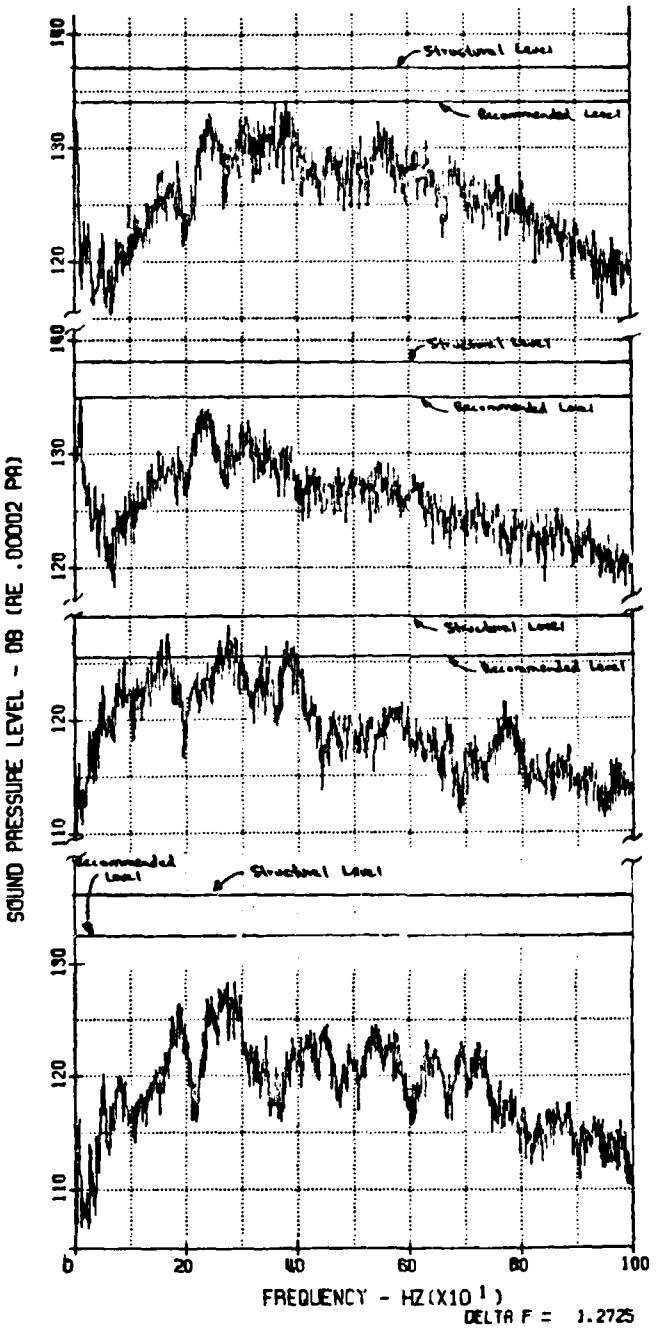


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Figure 6 (cont'd) Comparison of Sound Pressure Levels Measured During Maximum Afterburner (Record Number 24) and Allowable Noise Levels on F-4E Aircraft Structure

estimated life in hours for maximum A/B is (from Ref. 3) 7.5 hours. Since the F-4E aircraft was estimated to have 32 hours of ground run-up time at maximum afterburner (Ref. 2) during its lifetime, the life of 7.5 hours is less than the design requirement. Several recommendations concerning pertinent fix and inspection programs are offered to increase the fatigue life of the affected area. Placing a flexible blanket type cover around the fuselage to shield it from the jet exhaust noise will do the job. Another approach is to design a fiberglas shroud or barrier which will conform to the shape of the aircraft and fuselage. Still another approach would be to establish a periodic inspection program which will effectively monitor the occurrence of fatigue cracks. If the skin in the area under concern is increased one gauge thickness from 0.032 inches (0.08 cm) to 0.040 inches (0.10 cm), the estimated fatigue life will increase to approximately 56.5 hours. This is greater than the design requirement.

Figure 7 shows a comparison of one-third octave band spectra during maximum afterburner (A/B) for several selected microphones on the aircraft skin and similar locations during ground run-up (Ref. 4). The sound pressure levels (SPL) measured on the rudder (microphones 6 and 9) are less than those measured during run-up except for a few one-third octave bands. The measured spectra for the stabilator (microphones 11 and 14) are somewhat higher than ground run-up, but by no more than a few dB.

The SPLs measured on the stablator were a few dB greater than those measured during ground run-up. If these increases are present on other areas of the aircraft, fatigue and/or malfunction problems could be present with equipment pods and avionics. Equipment on-board the F-4E aircraft may not be qualified to the sound pressure levels reached during hush house

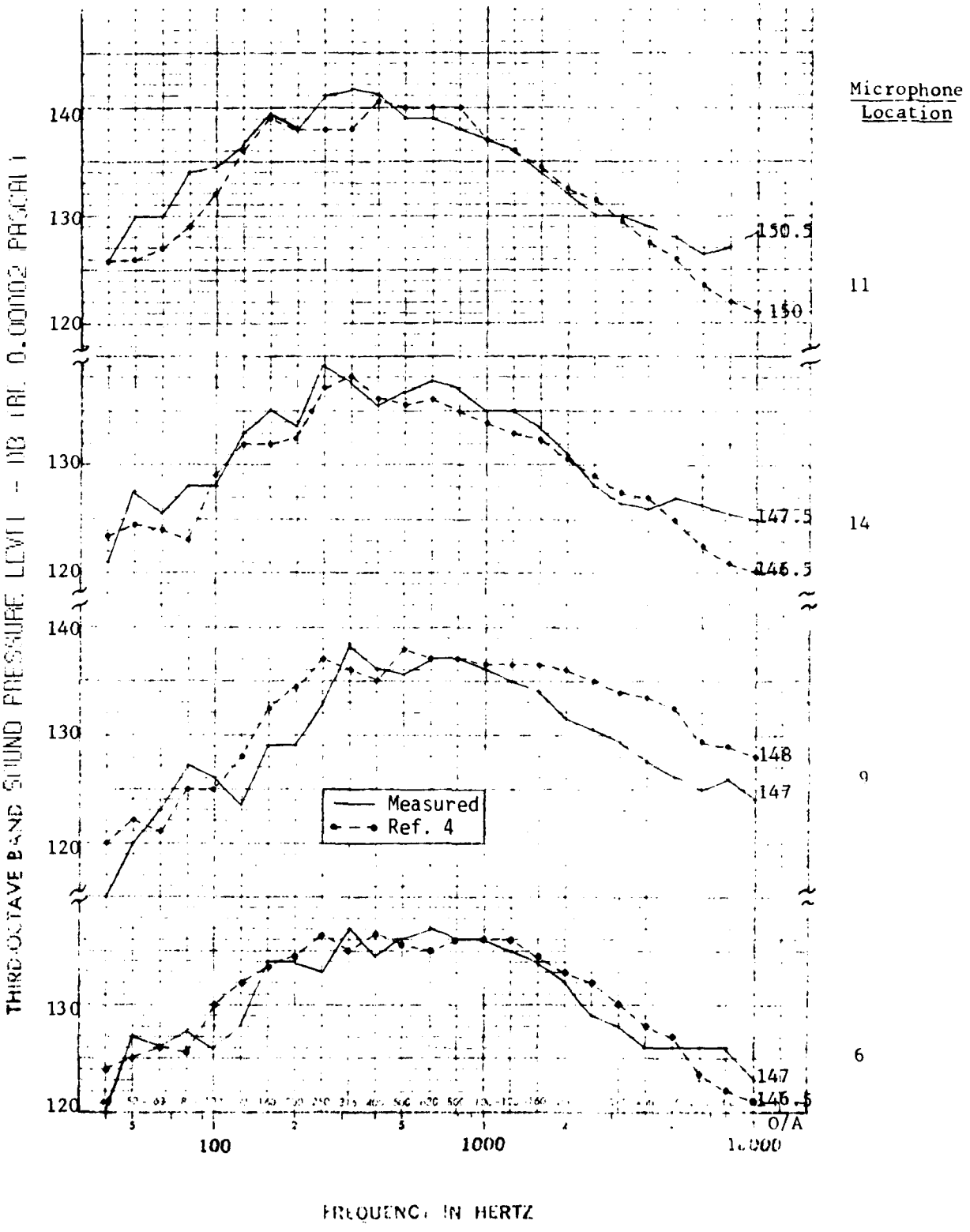


Figure 7 Comparison of One-Third Octave Band Spectra Measured in Hush House Near Aircraft Skin and Ground Run-up (Ref. 4)

operation and may be sensitive to acoustic excitation. The equipment could respond in such a manner that would modify or possibly disrupt its mode of operation or even result in mechanical failure. F-4E equipment qualification levels should be checked against the measured sound pressure level increases shown here to determine if the equipment have been qualified for this type of operation.

B. Sound Pressure Level at Top of Hush House Deflector and Far Field

Microphone 25 was located at the top of the hush house deflector to measure the sound pressure levels at this location. Figure 8 presents narrowband (0.5 hz) spectra for this microphone with the left (port) engine operating at maximum afterburner and the right (starboard) engine at idle (record number 23). Also shown is record number 21 with the port engine at military power and the starboard engine at idle. The sound pressure levels decrease rapidly with increasing frequency. The SPLs are highest at the low frequencies. It is these lower frequencies which will propagate long distances to the farfield. The SPLs increase 5-8 dB when going from military to maximum A/B power. This increase is consistent with that measured on the aircraft surface.

The spectra in Figure 8 for maximum A/B power were converted to equivalent one-third octave band sound pressure levels and plotted on Figure 9. Also plotted on Figure 9 are the sound pressure levels measured at a similar position to microphone 25 at NAS Miramar (Ref. 5). The Miramar data as plotted are for the #2 hush house with sound absorbing pillows installed in the muffler. The measured data are 0-7 dB less than the Miramar data between 8 and 80 hertz.

Since the farfield criteria for hush houses are presently in terms of A-weighted levels, this difference between the measured and Miramar data is of little consequence. However, if in the future the noise requirements for the

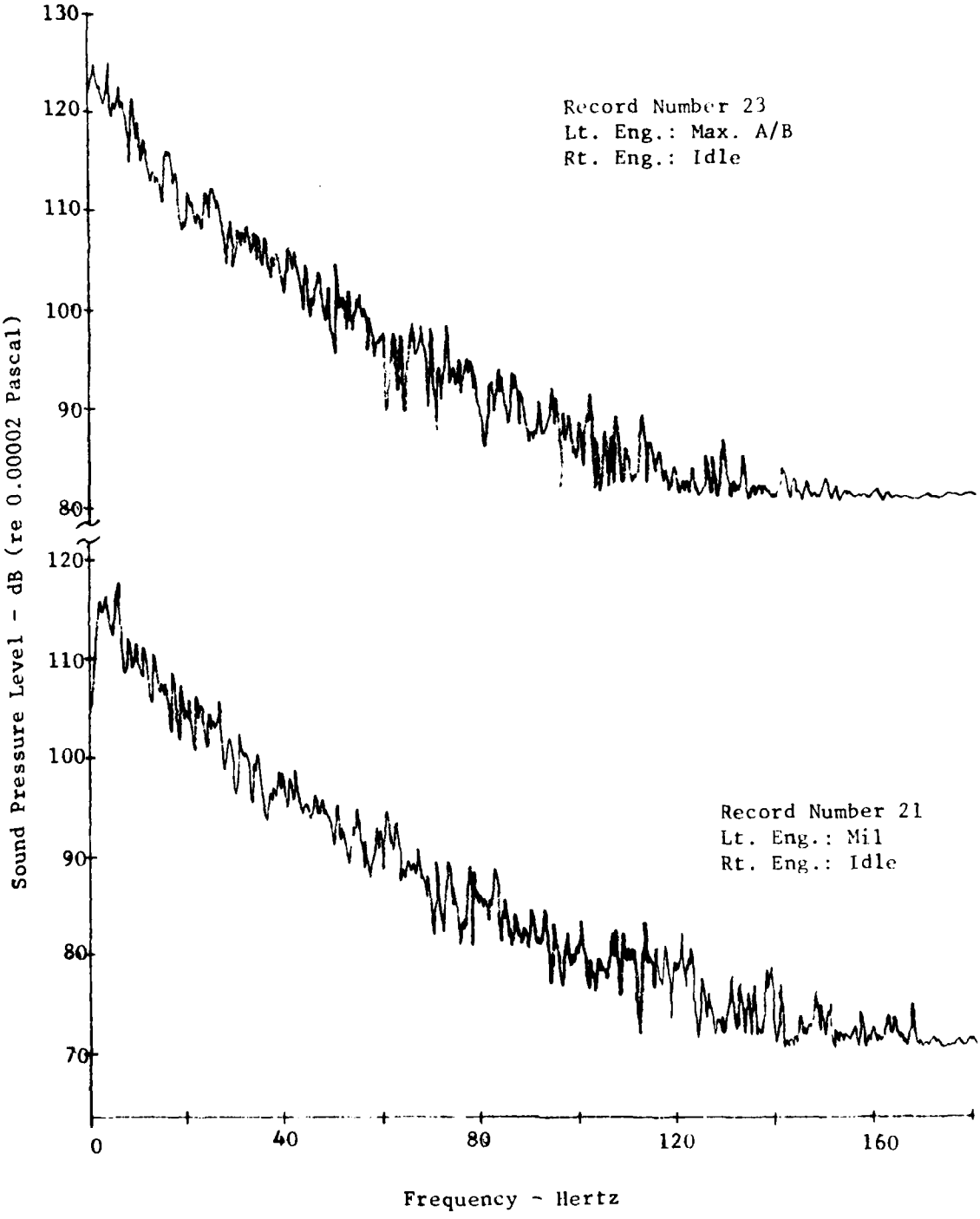


Figure 8 Narrowband (0.5 HZ) Spectra with F-4E Aircraft Operating in Hush House - Microphone 25

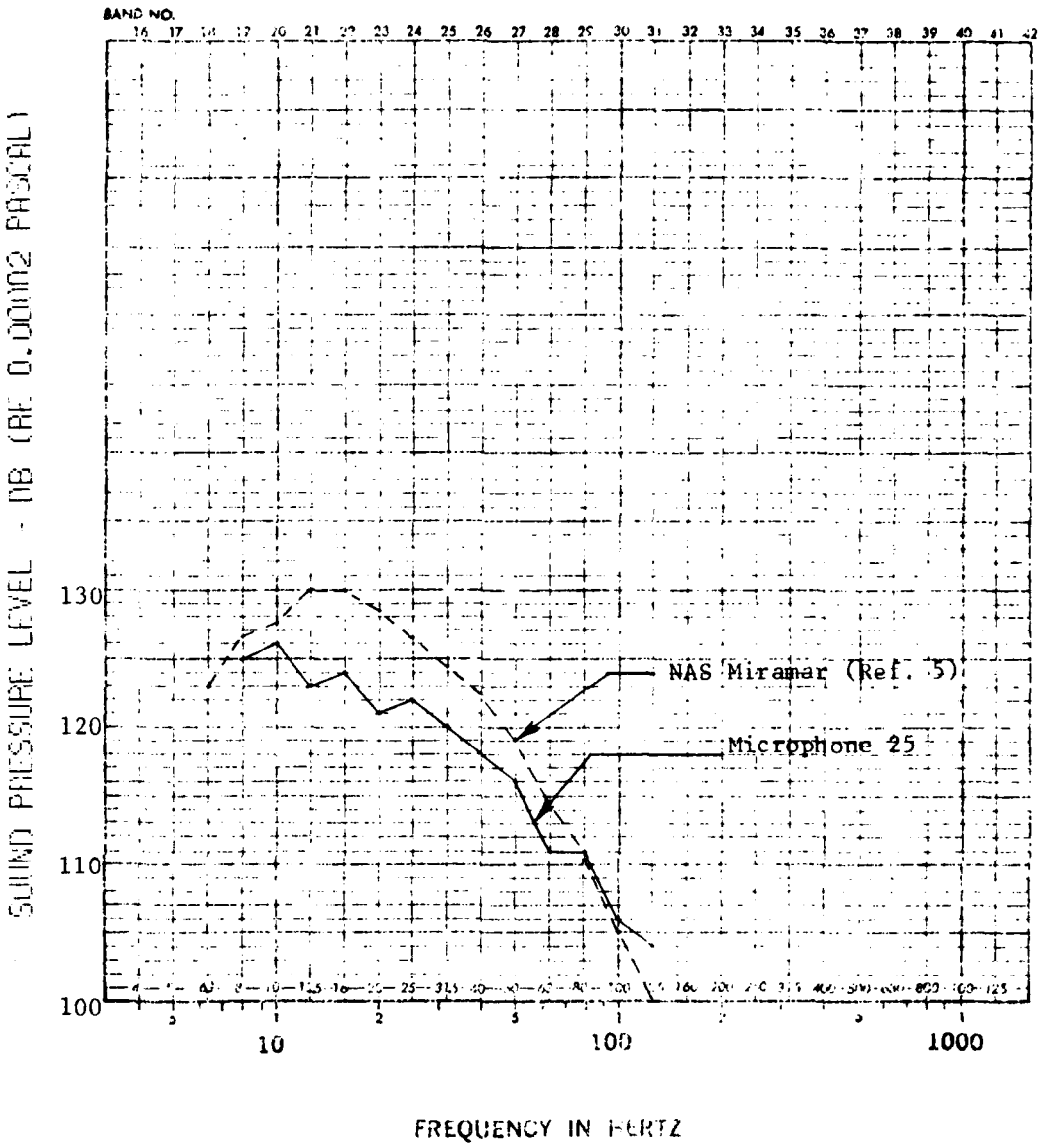


Figure 9 Comparison of One-Third Octave Band Spectra Measured during Maximum Afterburner (Record Number 23) at Microphone Location 25 and Corresponding Location at NAS Miramar (Ref. 5).

farfield are changed to place more emphasis on the octave band frequencies below 63 hertz, the Air Force hush house will have an advantage in lower sound pressure levels.

C. Sound Pressure Level at Maintenance Positions

Several different locations were measured in and around the aircraft to determine the noise environment for the personnel stationed in these areas during engine run-up. These microphones (16-17, 19-21, 24) were positioned at approximately the ear level of the personnel. Table 5 summarized the data at these locations in terms of A-weighted overall sound pressure level to assess the effects of noise on personnel and their performance. Data included in this table are for maximum A/B (record number 24). Four entries are made in this table. The first entry is for no hearing protection with the other entries for ear protection commonly used in ground crew environments for which limiting exposure times were provided (Ref. 6). Air Force Regulation 161-35 (Ref. 7) sets forth the exposure limitations for the protection of hearing in terms of the A-weighted overall sound pressure level and length of time exposed daily. Table 5 shows that some form of ear protection will be required at all locations shown. The amount of protection ultimately needed will be a fraction of the location and exposure time. The ground communication unit should probably be adequate for most situations.

D. Near Field

The noise environment at positions to the side of the aircraft is summarized in Figure 10. These locations are major maintenance positions where personnel may be stationed during normal trim run-up operations. This figure includes the measured data as well as similar locations and engine power conditions from ground run-up in the free field (Ref. 8 and 9) and from the NAS Miramar hush

TABLE 5 MEASURE OF HUMAN NOISE EXPOSURE DURING F-4E AIRCRAFT ENGINE OPERATION AT MAXIMUM AFTERBURNER (Record Number 24)

Type of Protection	A-Weighted Overall Sound Pressure Level, dBA*/Maximum Permissible Time, Minutes					
	Mic 16	Mic 17	Mic 19	Mic 20	Mic 21	Mic 24
No Protection	141/P	137/P	132/P	138/P	132/P	130/P
Minimum QPL Ear Muffs	116/P	112/3.8	107/9	113/3.2	107/9	105/13
H-133 Ground Communication Unit	112/3.8	108/8	103/18	109/6	103/18	101/25
American Optical 1700 Ear Muffs Plus V-51R Ear Plugs	100/30	96/60	91/143	97/50	91/143	89/202

* Based on calculated SPL spectrum under protective device.

P Additional ear protection required.

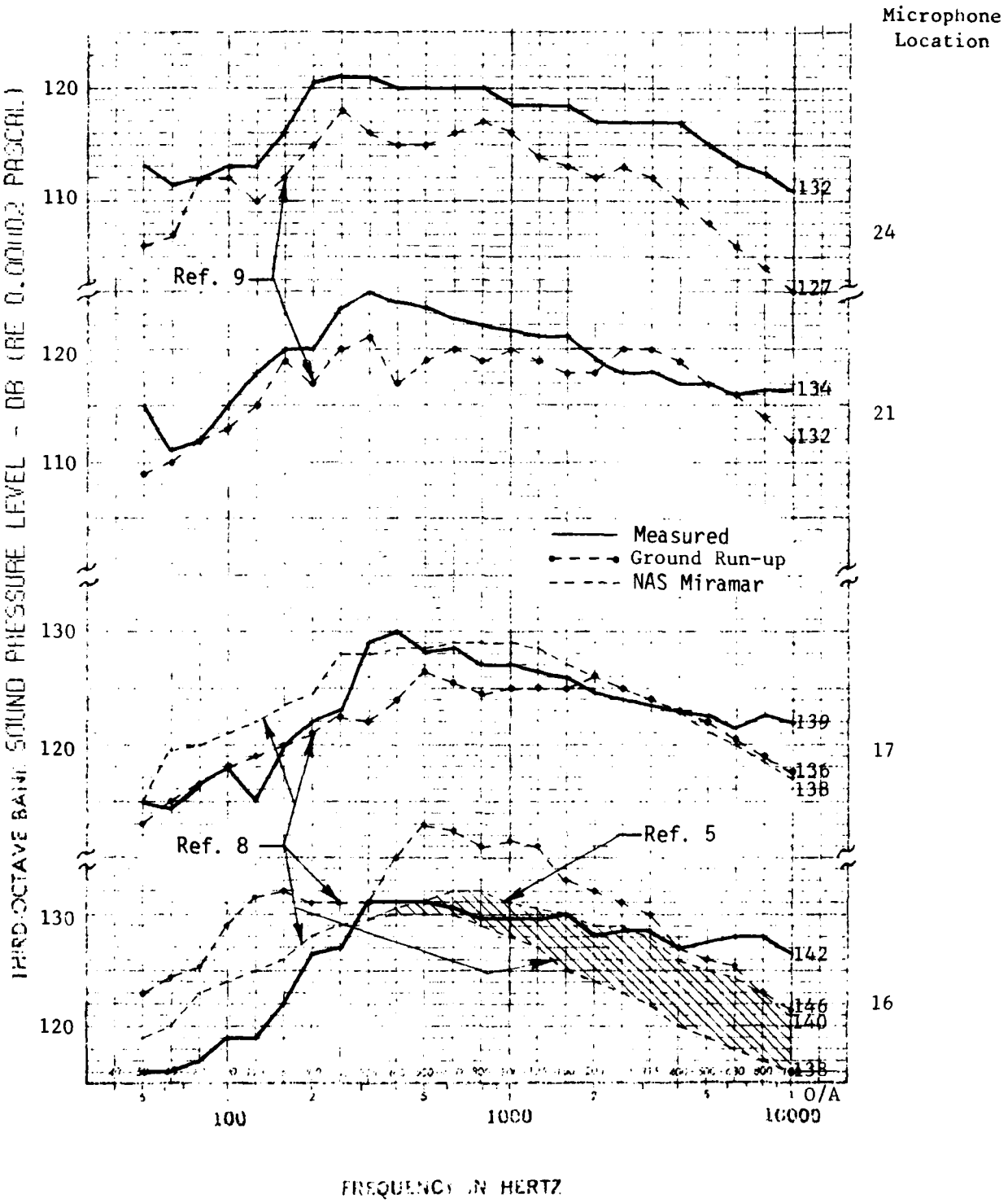


Figure 10 Comparison of One-Third Octave Band Spectra Measured in Hush House, Ground Run-up (Ref. 8&9), and NAS Miramar (Ref. 5 and 8).

house (Ref. 5). While the measured sound pressure levels in the hush house in the region toward the nose of the aircraft (mic 21, 24) are generally higher than free field, the measured hush house SPLs toward the tail of the aircraft (mic 16) are significantly less (12 dB), especially at frequencies less than 315 hertz. Comparison of measured SPLs with the NAS Miramar data shows the measured data are 0-6 dB less in the low frequencies (below 250 hertz).

Another way to compare the noise environment in the hush house to that existing when the aircraft is operated in the ground run-up on a concrete pad is to compute the average SPL from the data from microphones 16, 17, 21, and 24, in Figure 10. This average SPL inside the hush house together with the range is given in Figure 11. On this same figure is similar data for ground run-up. The range of SPL in the hush house is relatively small when compared to ground run-up.

A series of contours of equal SPL in 2 dB steps for one-half of the hangar area for the overall level and the octave bands from 63 to 8000 hertz is given in Figure 12. This figure shows that the sound energy in the hangar area is radiated between the engine exhaust plane and the entrance to the muffler toward the forward part of the hangar area. Energy is reflected back from the muffler to the hangar area together with that generated in the gap between the aircraft engine and the muffler opening. The jet nozzle exits on the F-4E are located far forward of the tail so that a large portion of the high frequency noise producing region of the jet is located in front of the muffler. The higher frequency energy is radiated directly into the hangar area rather than the muffler. These higher frequencies could be lowered by proper positioning of the engine exhaust relative to the entrance to the muffler. However, since the engine exhausts are far forward of the tail, the

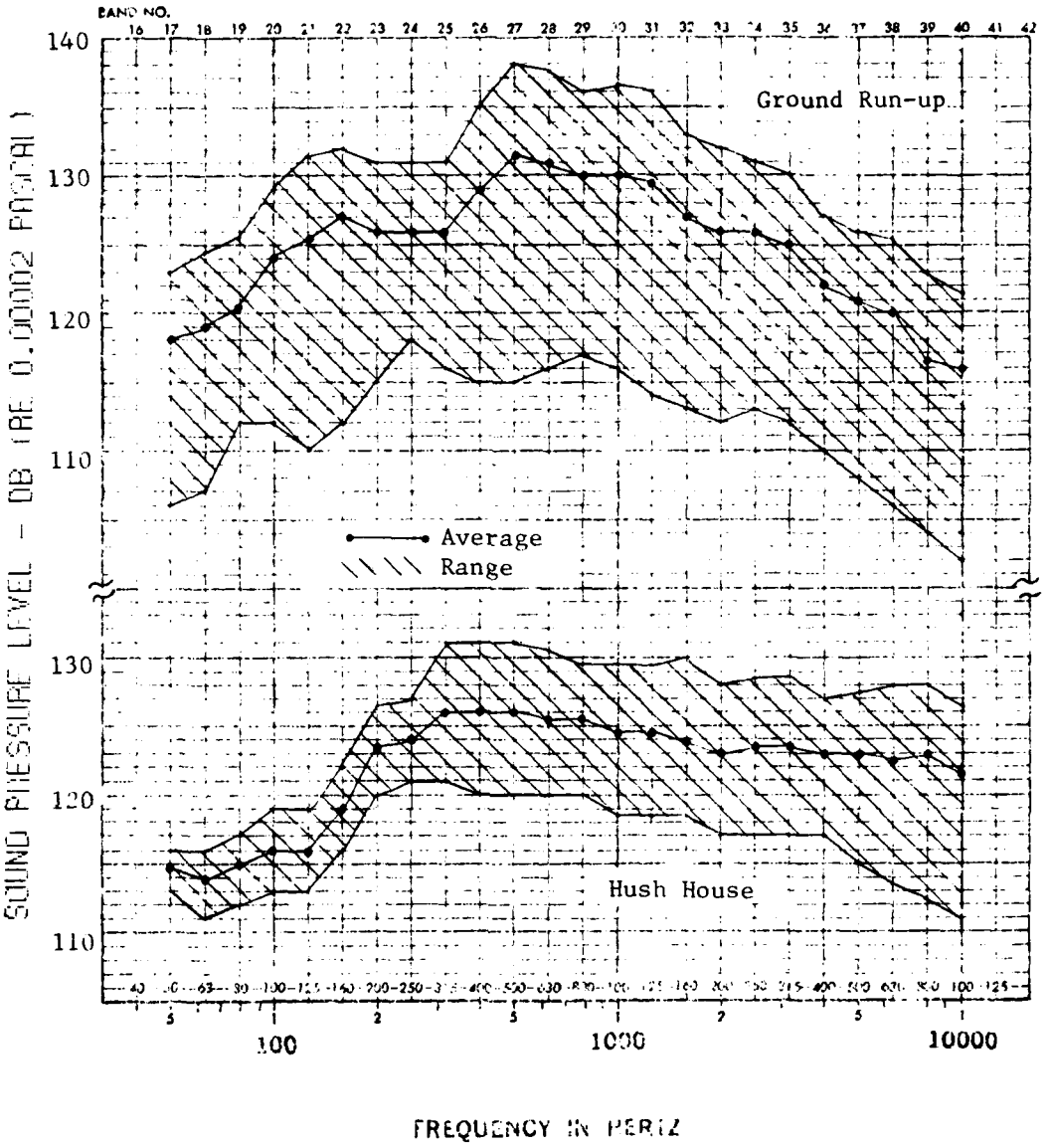


Figure 11 Average SPL and Range for Positions in Hush House and Ground Run-up (Ref. 8 & 9)

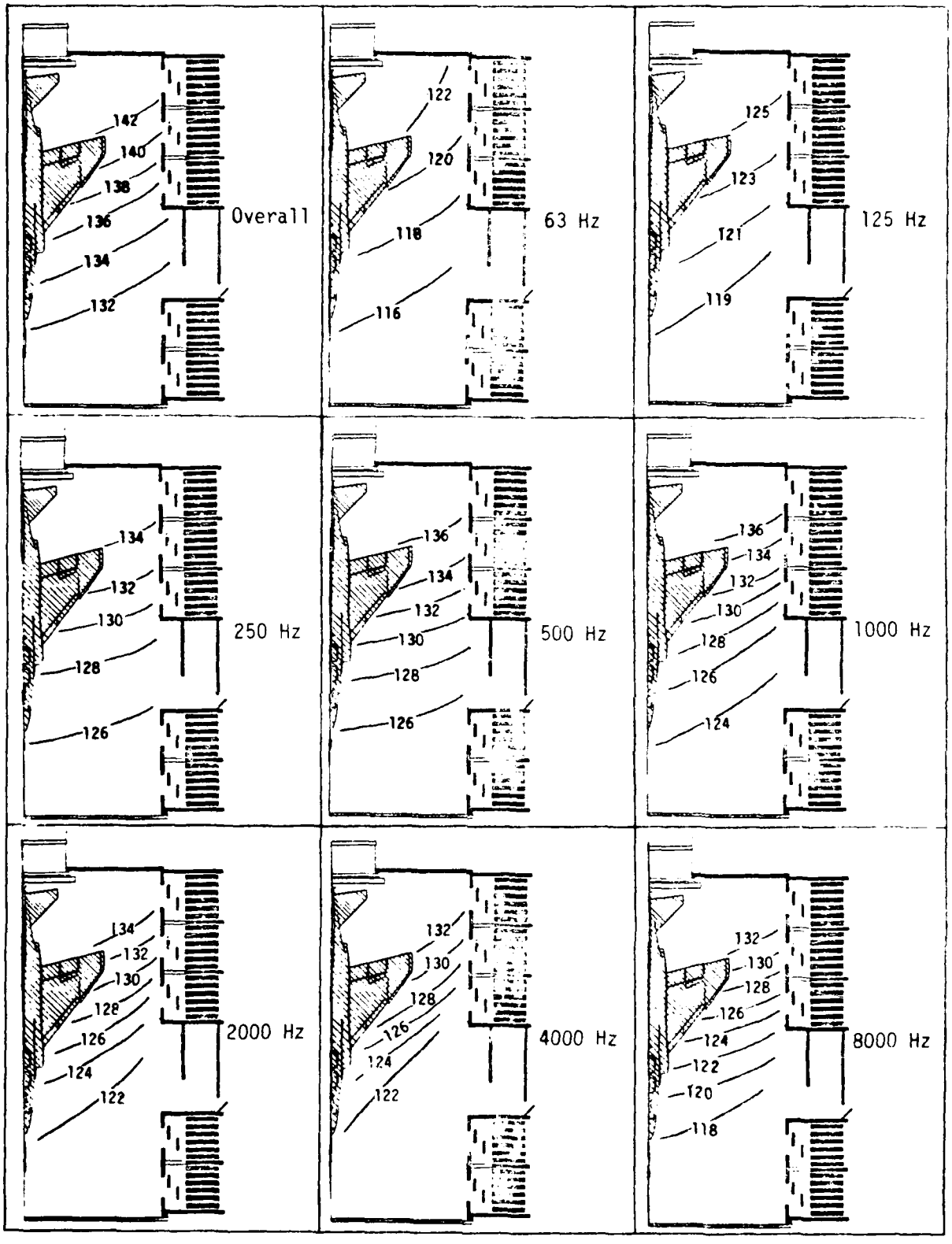


FIGURE 12 Smoothed Overall and Octave Band Contours of Equal Band Sound Pressure Level Inside Hangar Area with F-4E Aircraft Operating Left Engine at Maximum Afterburner and Right Engine at Idle.

distance between engine exhaust and muffler opening could not be shortened for the F-4E because of clearance problems associated with the rudder and stabilator. The distance between the SPL contours in Figure 12 in the back portion of the hangar area tends to decrease with increasing frequency. This is indicative of the increased absorption at the higher frequencies provided by the acoustically treated hangar walls. For example, the SPL decreases only 4 dB from the wing tip to the leading edge of the fuselage in the 63 hertz octave band. However, in the 8000 hertz octave band the decrease is approximately 14 dB.

V. CONCLUSIONS

1. Structural damage due to sonic fatigue is anticipated with the F-4E aft fuselage aircraft structure during operation in the hush house hangar area at maximum afterburner. The measured data for the aircraft aft fuselage are 5 dB greater than the structural design level limits. The fatigue life for this region of the aircraft is less than the design requirement.
2. Sound pressure level increases of 0-3 dB were measured on the F-4E stabilator when comparing ground run-up and in the hush house hangar area.
3. Ear protection will be needed for personal stationed in and around the F-4E aircraft while operating in the hush house.
4. The measured sound pressure levels in the hush house near field are 0-6 dB less than those measured in the NAS Miramar hush house below 250 hertz.
5. The measured data at the top of hush house deflector are 0 to 7 dB less than those measured at NAS Miramar between 8 and 80 hertz.

VI. RECOMMENDATIONS

1. Several fixes are recommended to increase the fatigue life of the aft fuselage: design a shroud or shield to conform to the shape of the aft fuselage, increase skin thickness one gage, or; establish a periodic inspection program which will effectively monitor the occurrences of fatigue cracks.

2. F-4E aircraft equipment qualification levels should be checked against the measured sound pressure levels to determine if the equipment has been qualified for this type of operation.

3. Vibration qualification test requirements for internal avionics should be made based on hush house operation since it is the highest noise environment.

4. Hearing protection should be worn by personnel in and around the F-4E aircraft during operation in the hush house.

APPENDIX A: PHOTOGRAPHS OF TEST SET-UP

Some of the photographs which were taken at the test site are included here. These photographs will serve to give the reader a better idea of where transducers were located, how the aircraft was positioned in the hush house, etc. These photos were furnished courtesy of the Base Photography Branch at Kelly AFB, Mr. M. A. Hart of AFWAL, and Mr. R. J. Reilly, consultant to ASE, Inc.

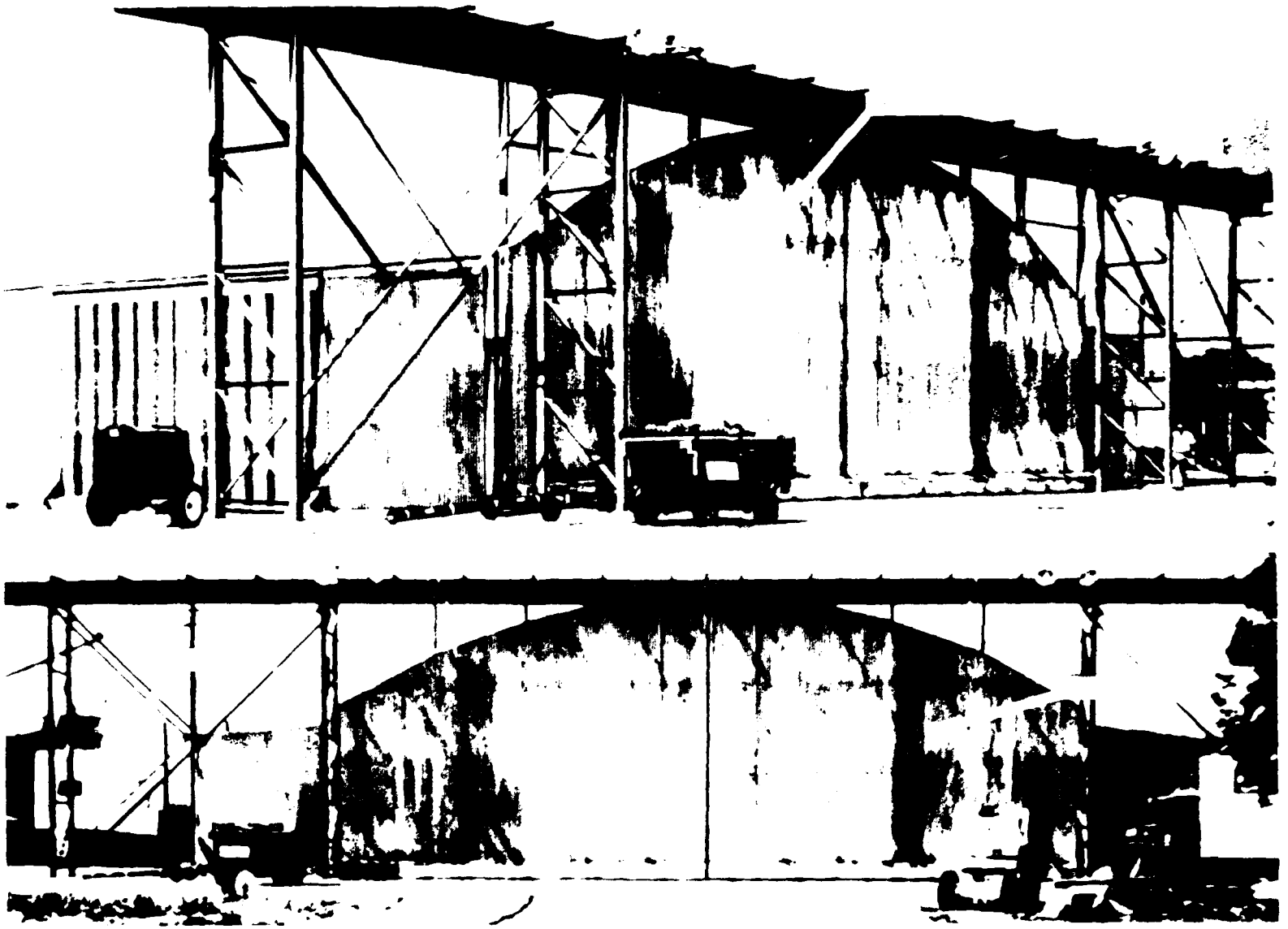


FIGURE A1 Location of FDL Mobile Data Acquisition Van Next to Hush House

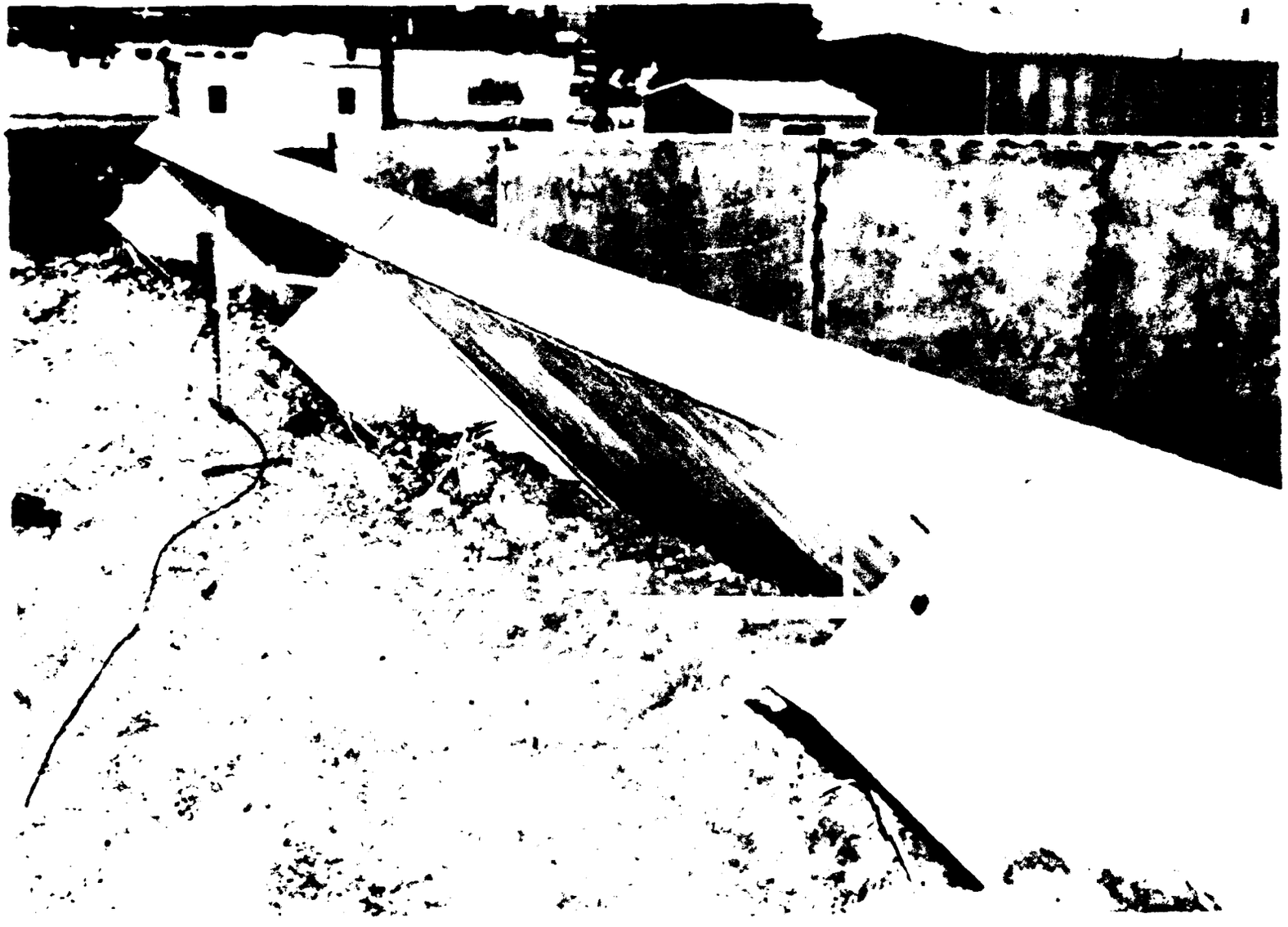
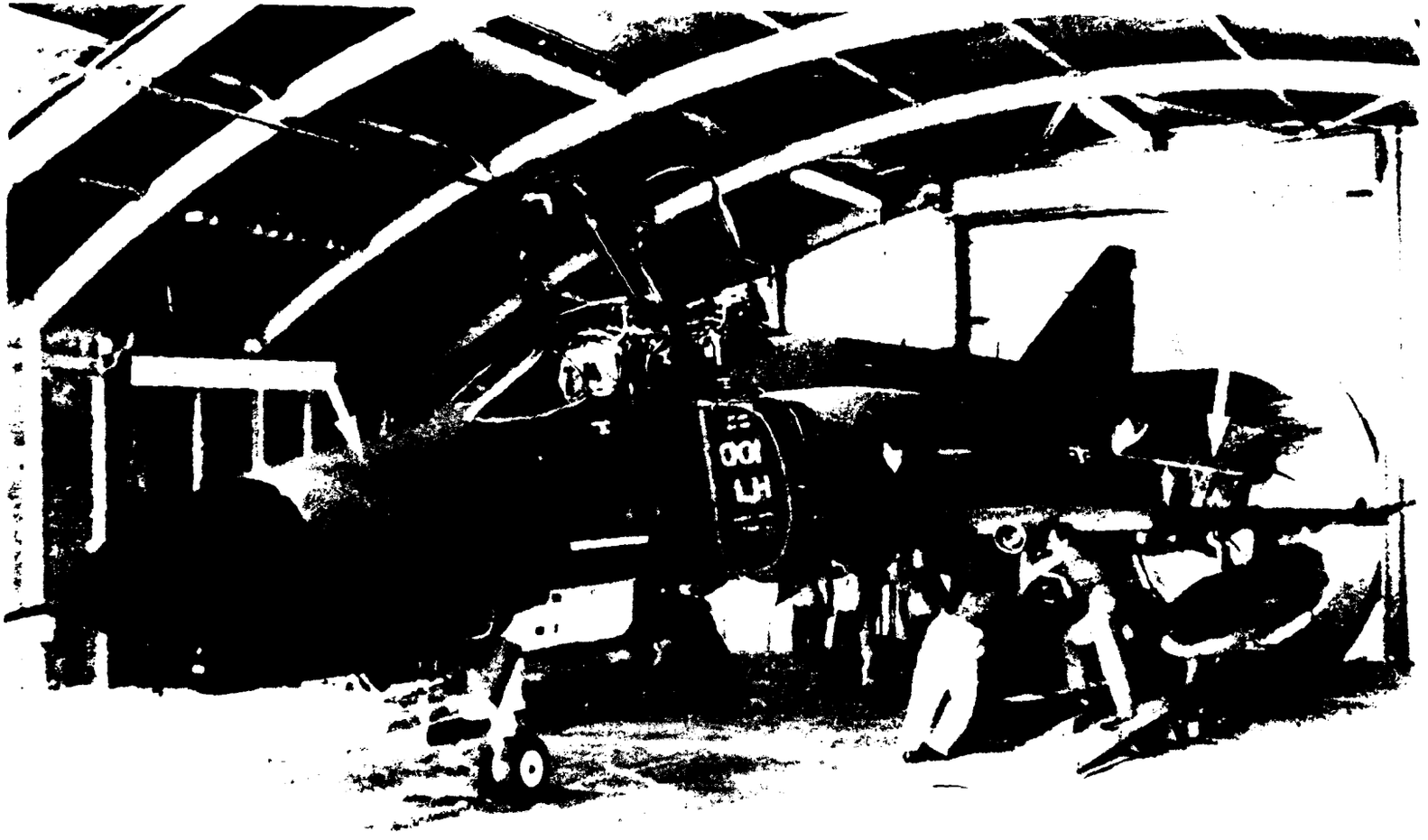


FIGURE A2 Location of Microphone 25 Next to Hush House Deflector


001
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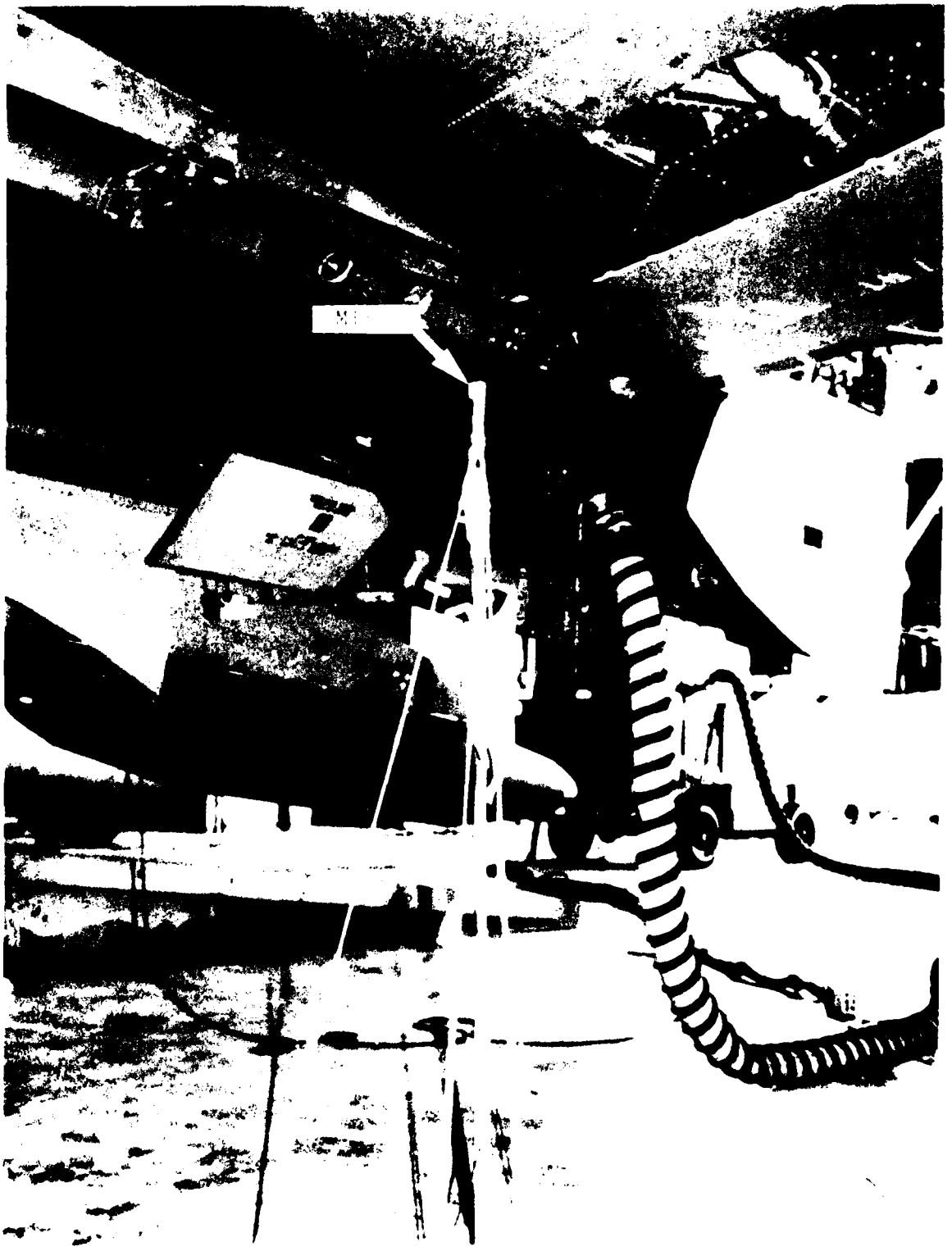

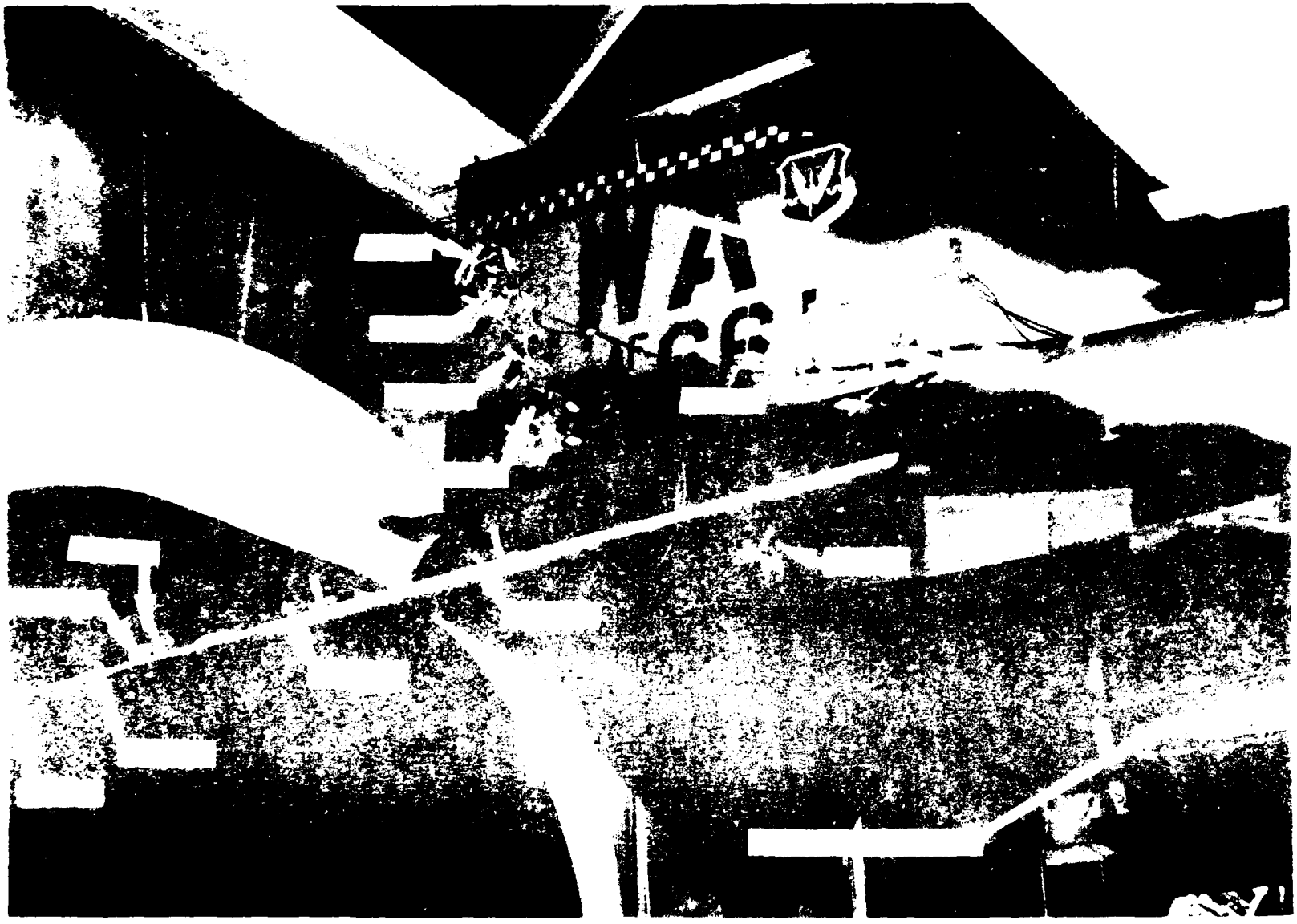

APPENDIX B. REDUCED DATA

The data which were recorded and analyzed from the test conditions identified in Table 1 are included here. The one-third octave band sound pressure levels for all 24 microphones are shown in Figures B1 through B21. Figures B22 through B26 give the A-weighted overall sound level spectra for microphones 16, 17, 20, 21, and 24. Narrowband (1 hz) spectra for microphones 1 through 14 are shown in Figures B27 through B54.

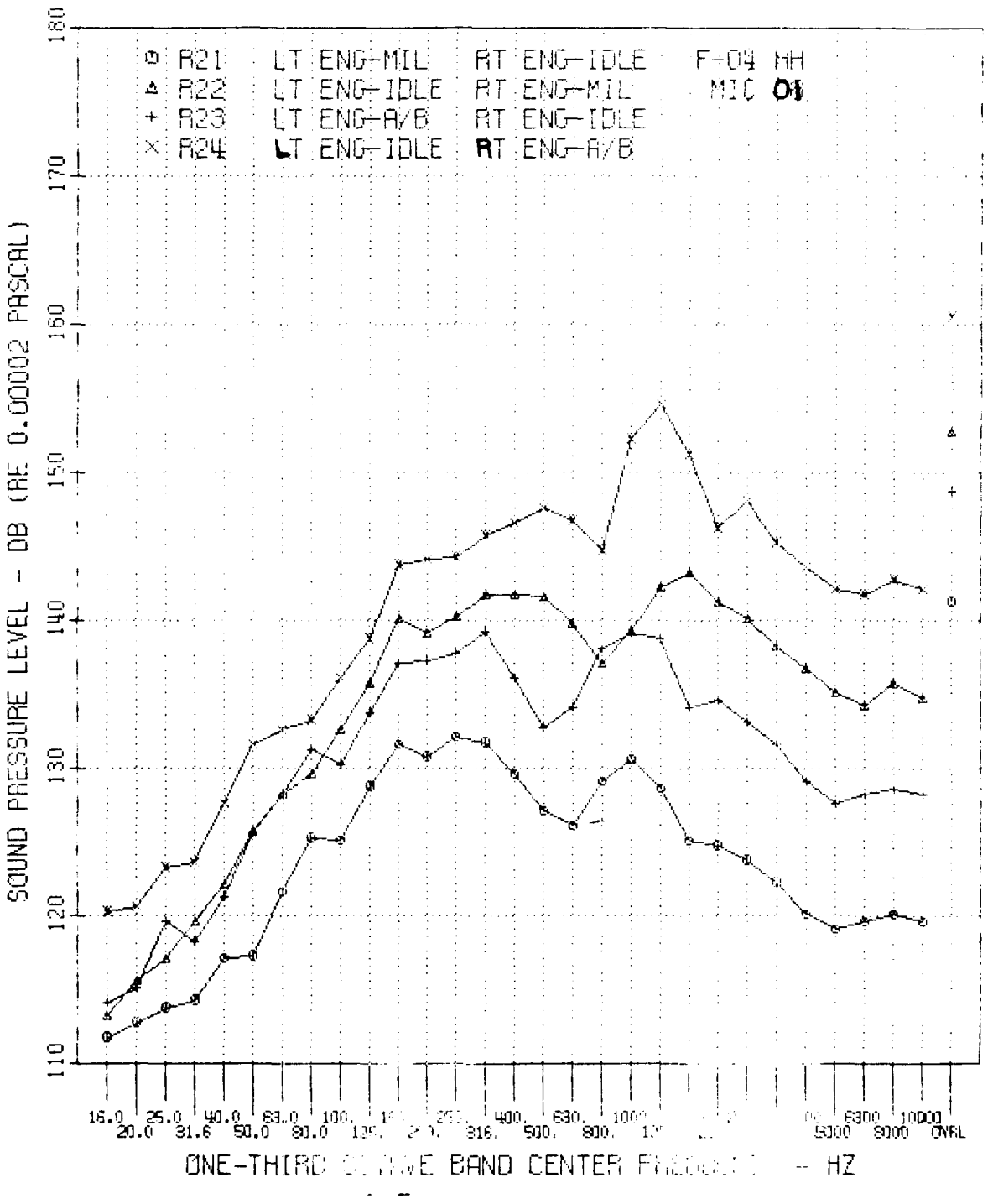

FIGURE B1 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 1.

GRAPH 6

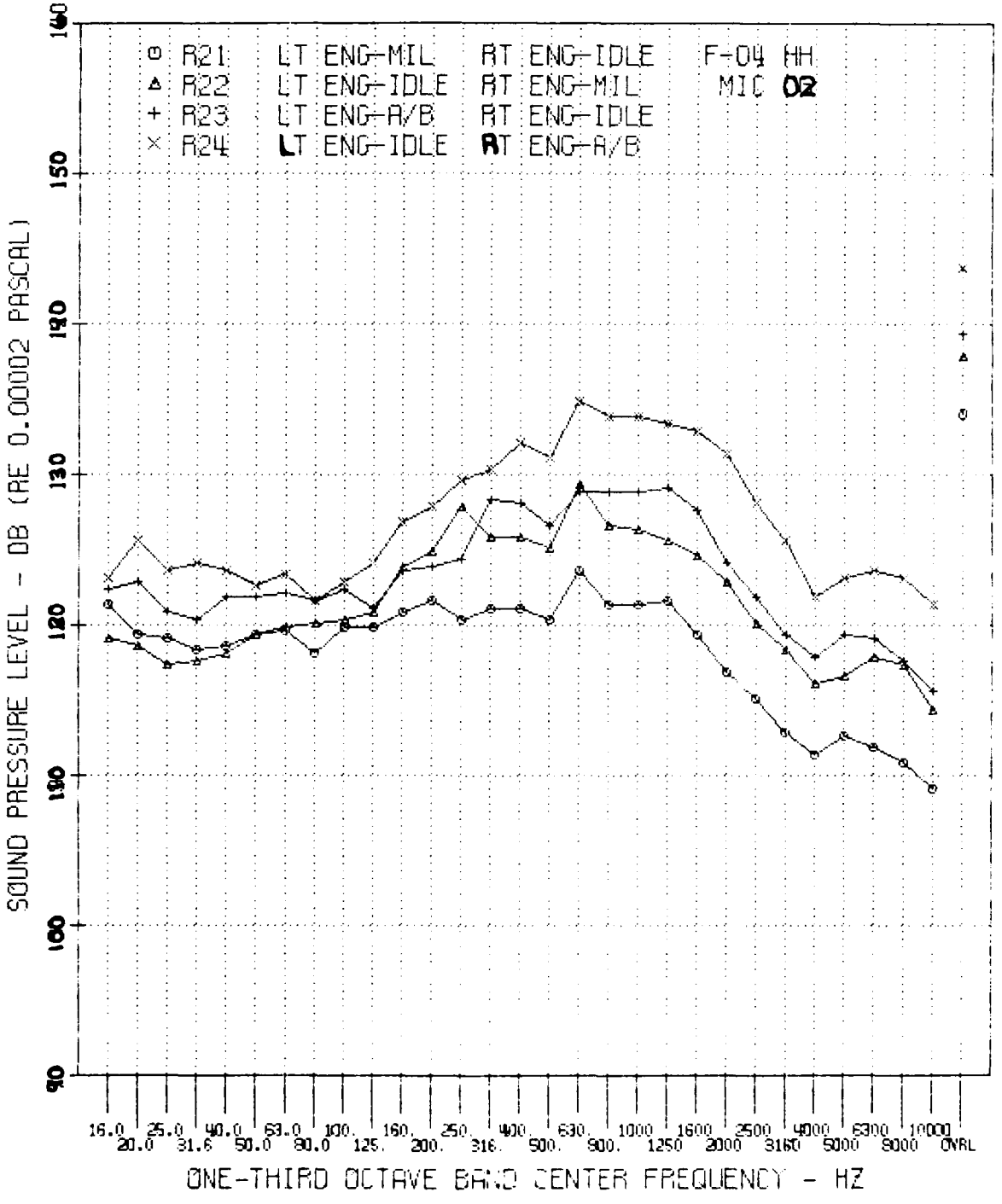

FIGURE B2 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 2.

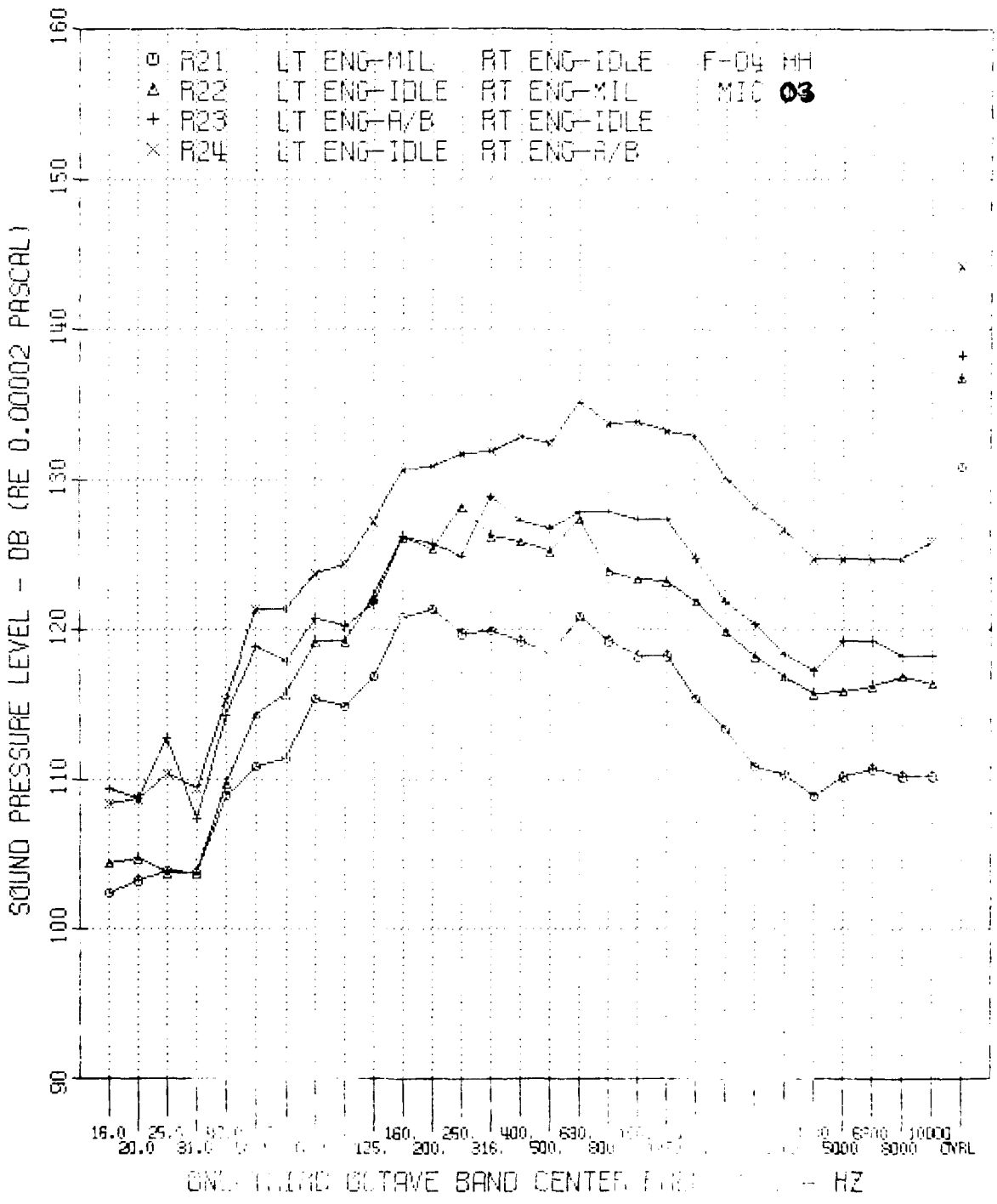

FIGURE B3 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 3.

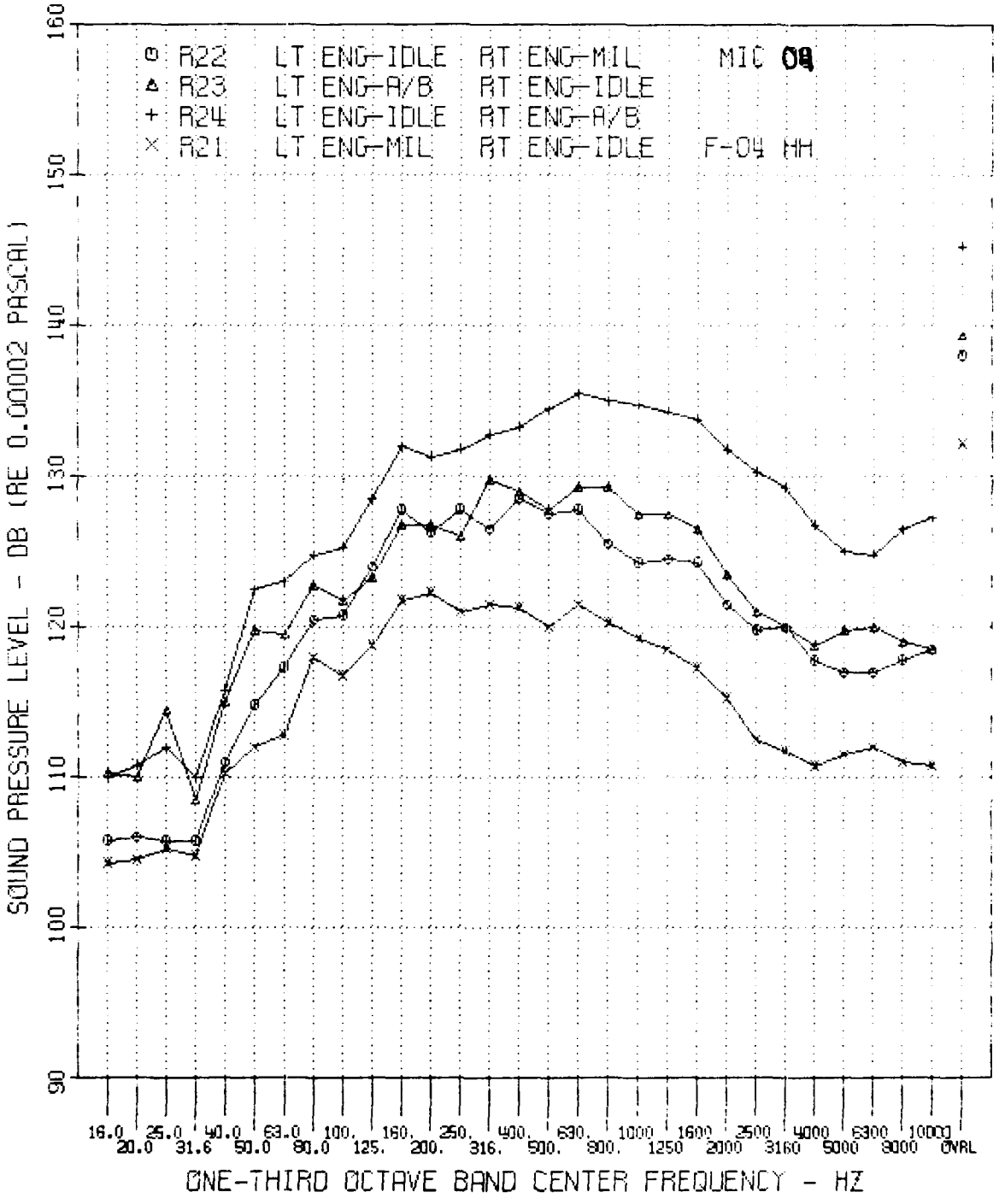

FIGURE B4 One-Third Octave Band Spectra for F4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 4.

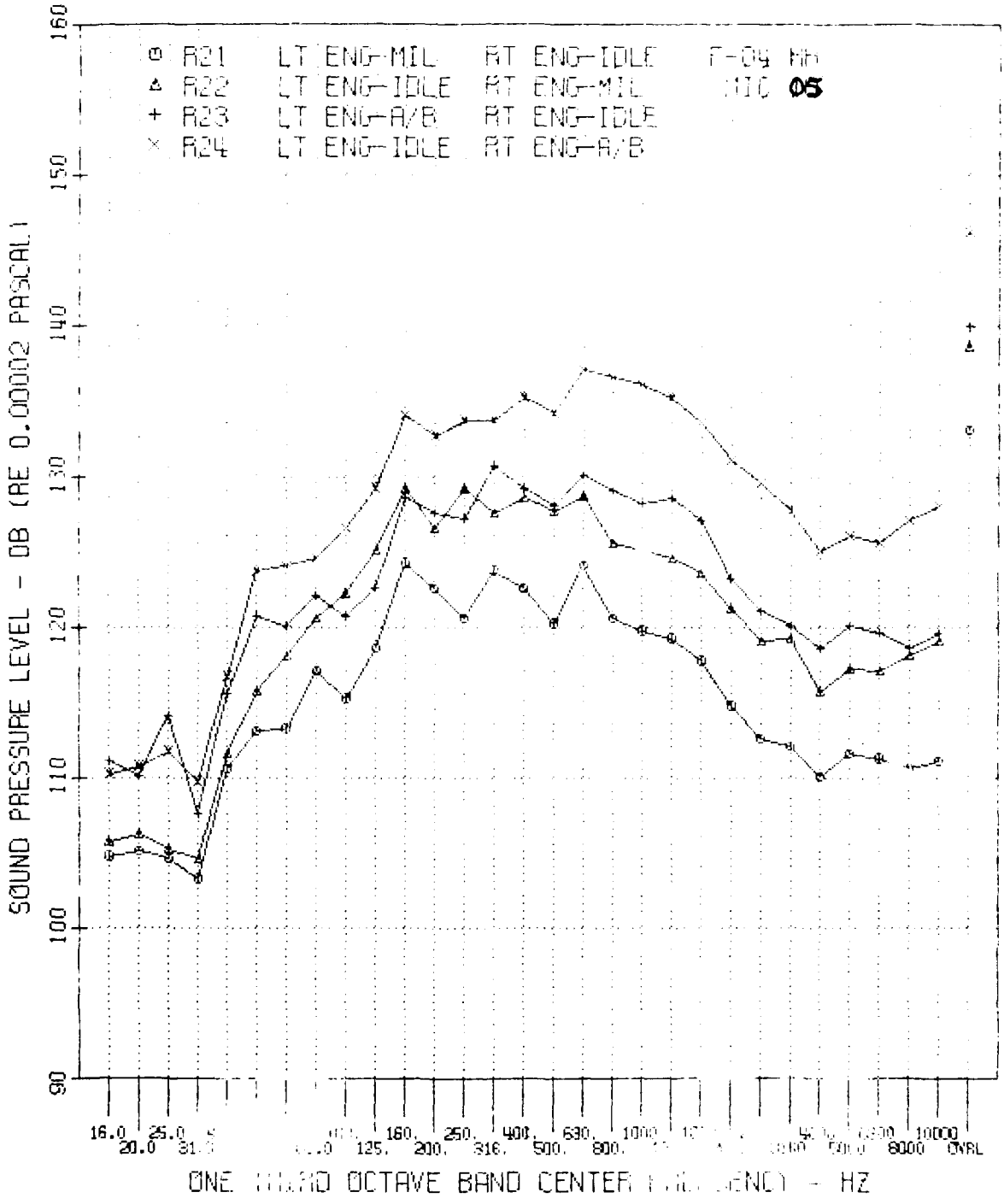

FIGURE B5 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 5.

GRAPH 2

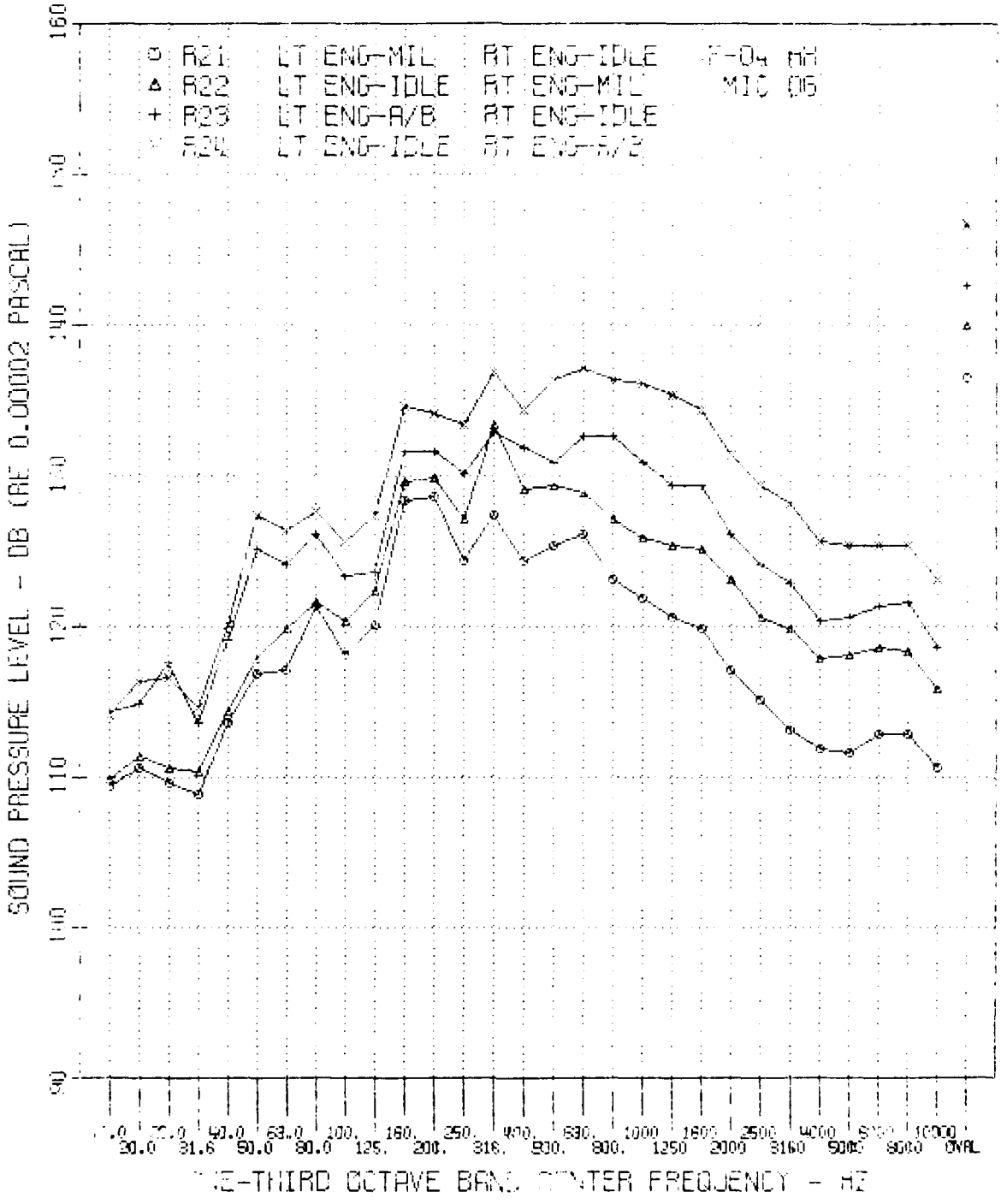

FIGURE B6 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 6.

GRAPH 12

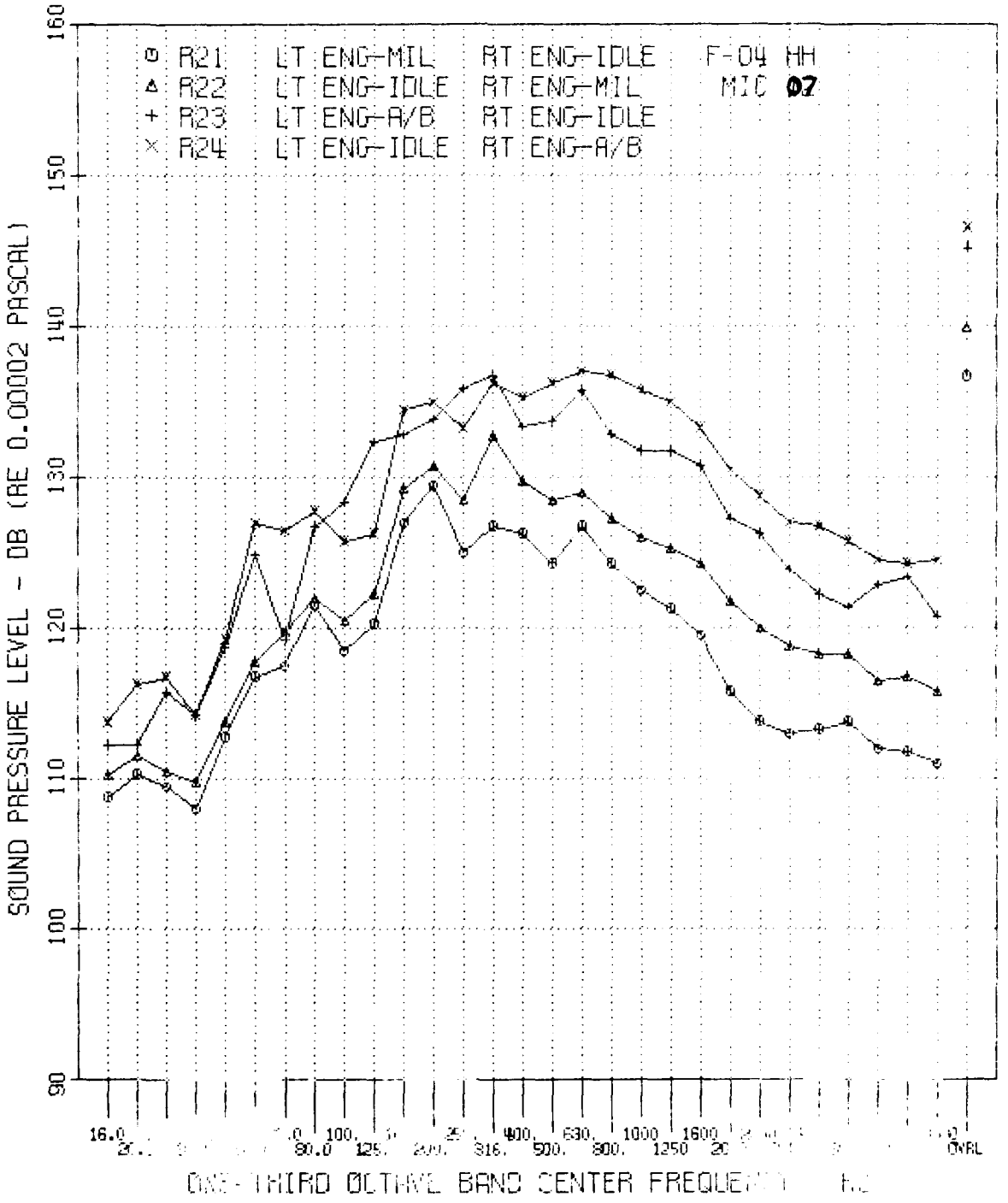

FIGURE B7 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 7.

GRAPH 13

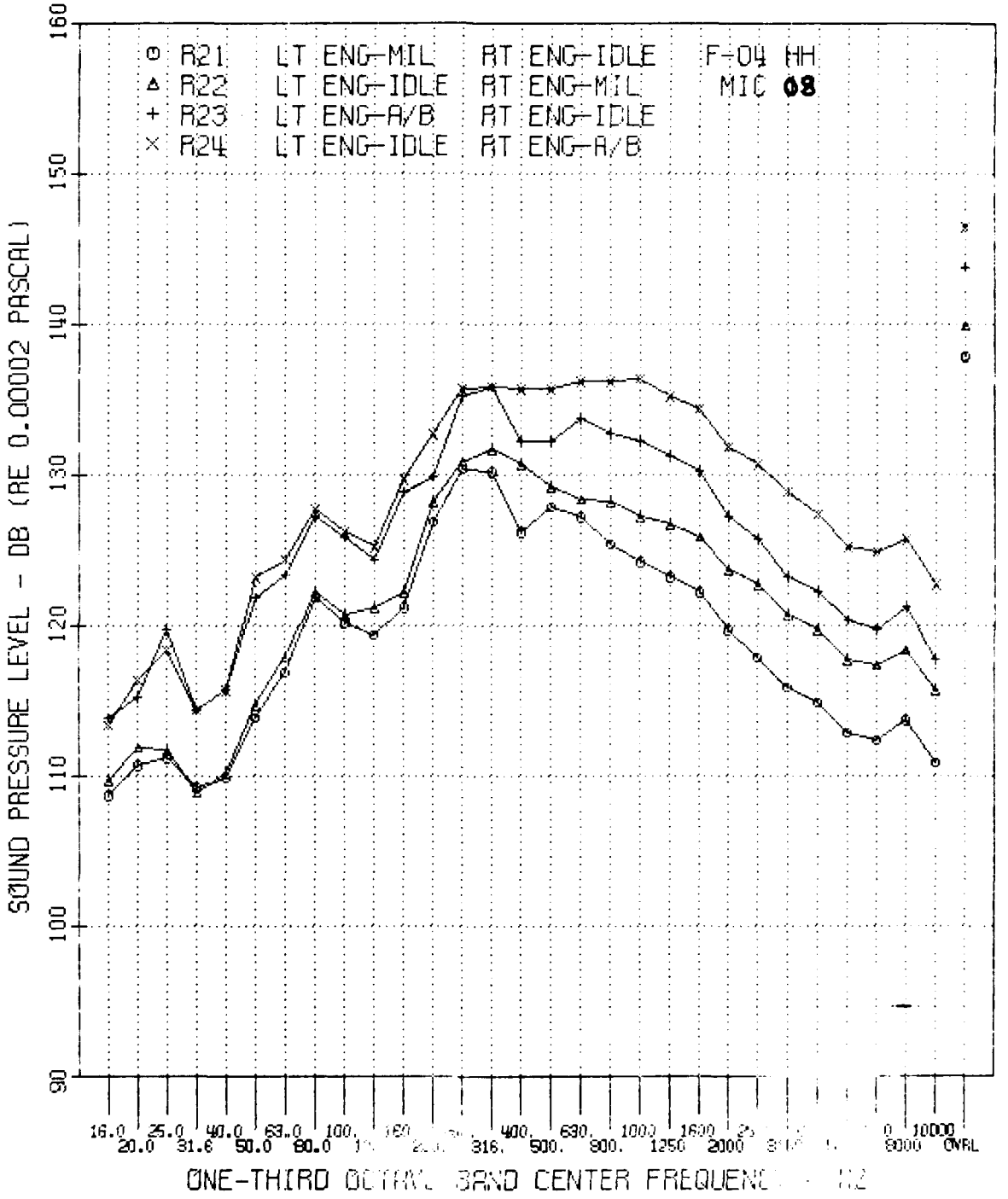

FIGURE B8 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 8.

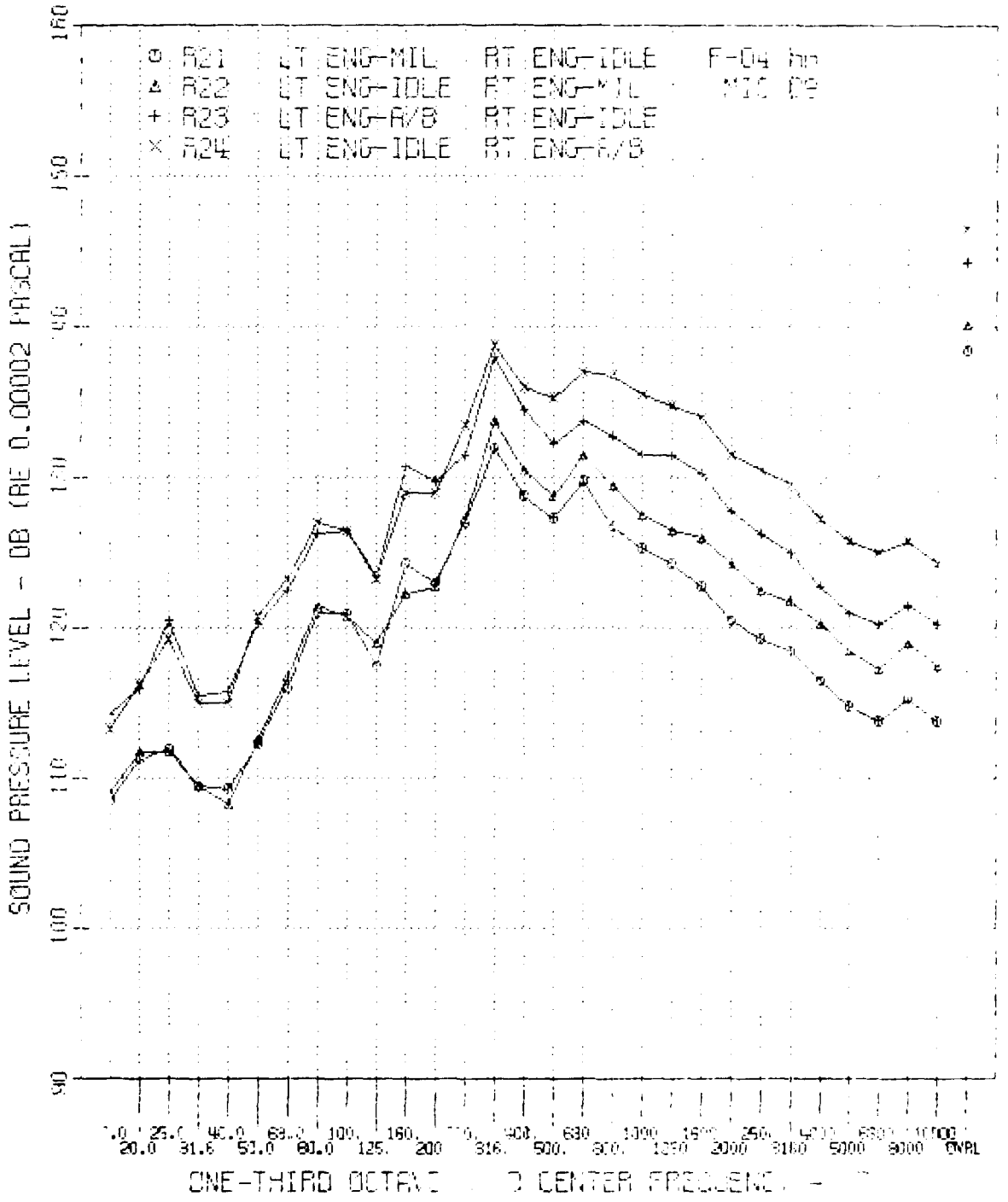

FIGURE B9 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 9.

GPH 11

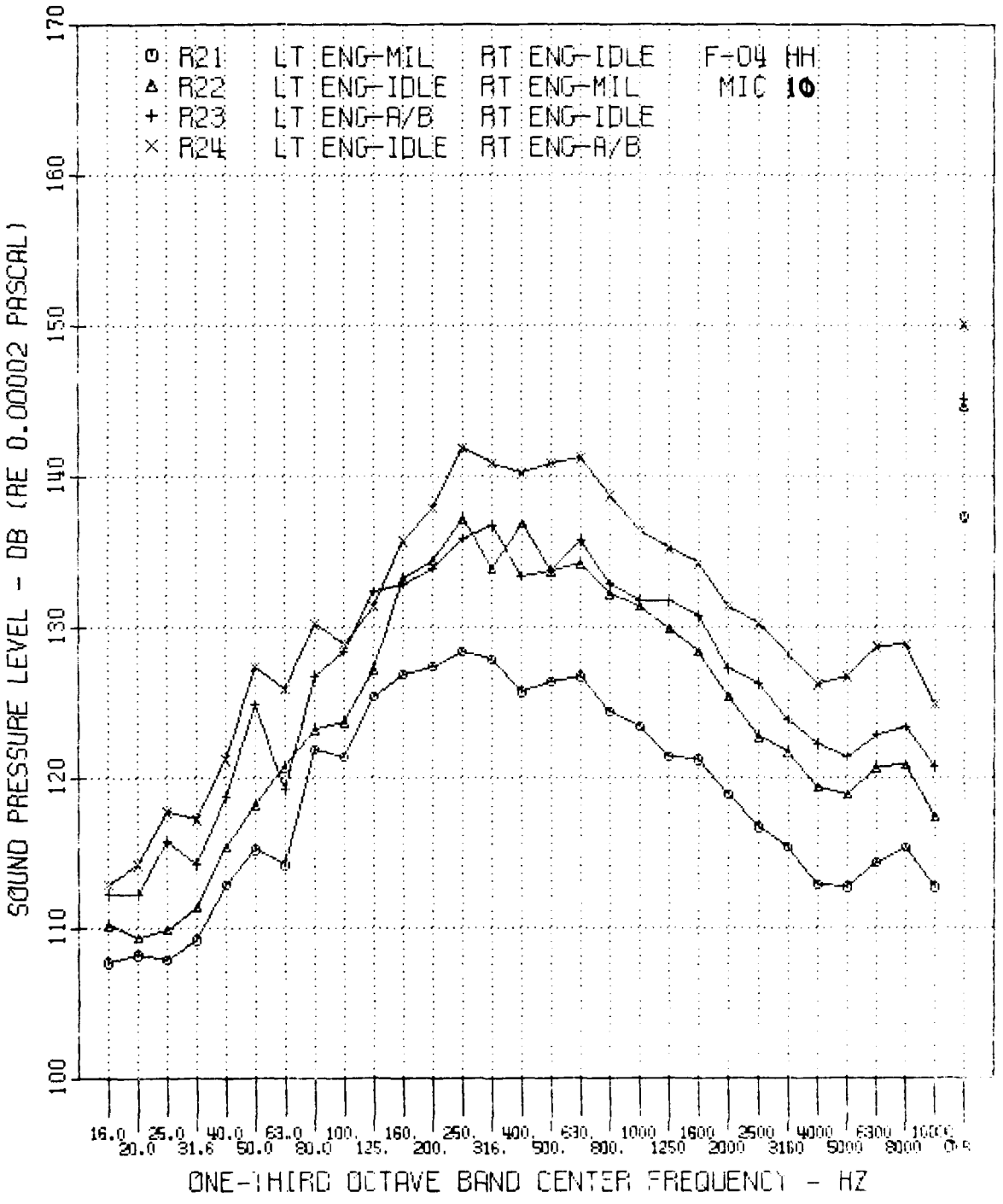

FIGURE B10 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 10.

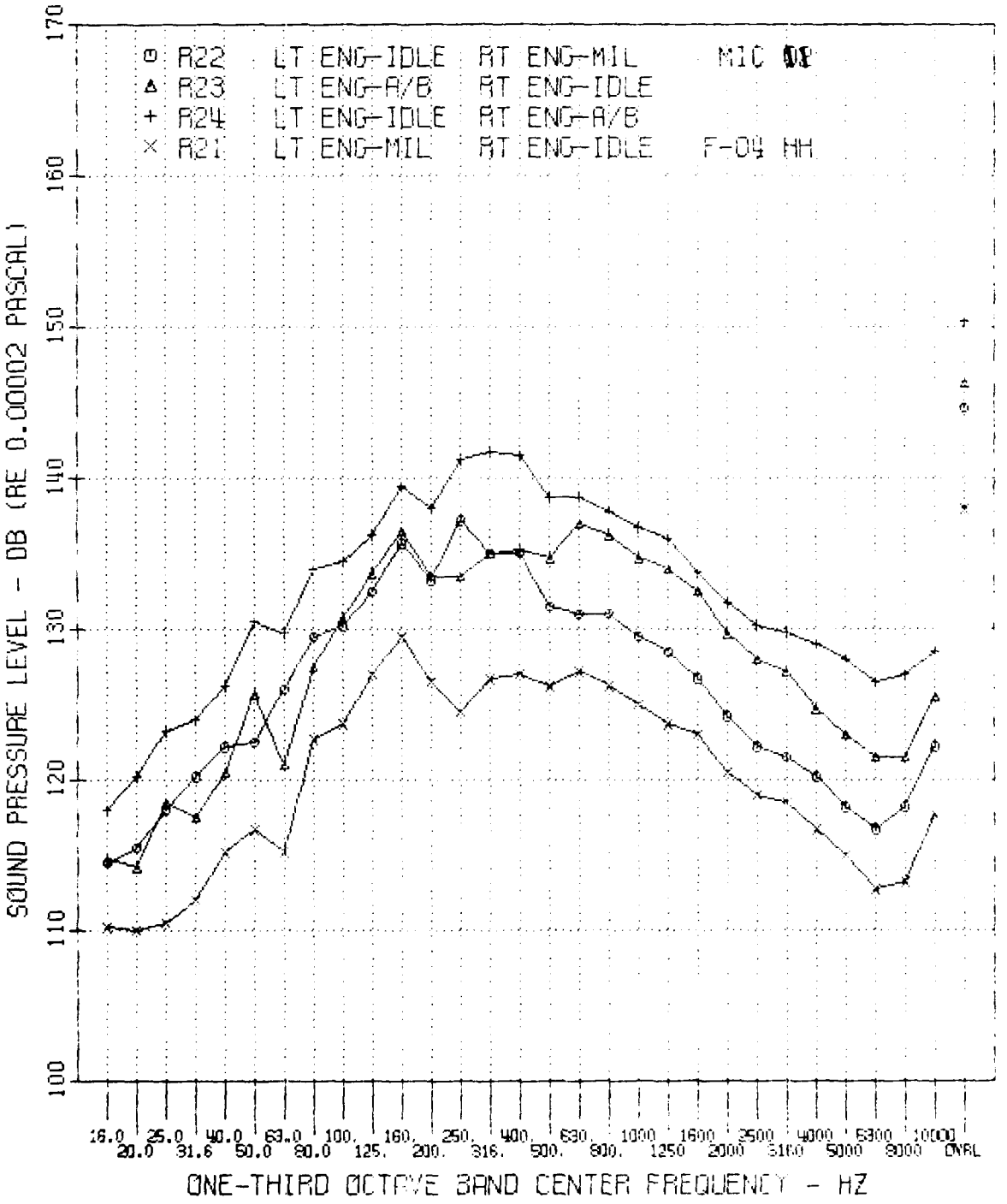

FIGURE B11 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 11.

GRAPH 5

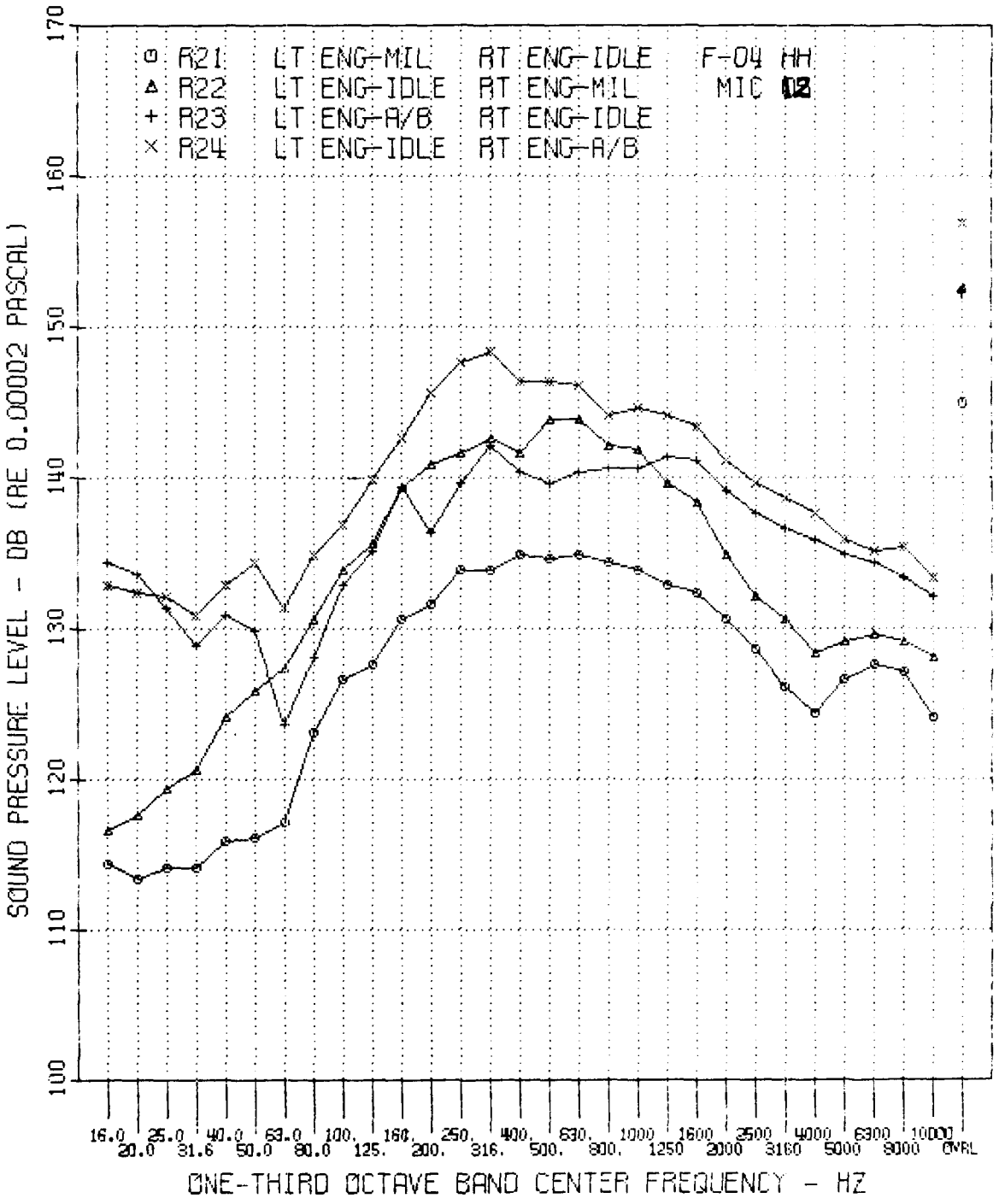

FIGURE B12 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 12.

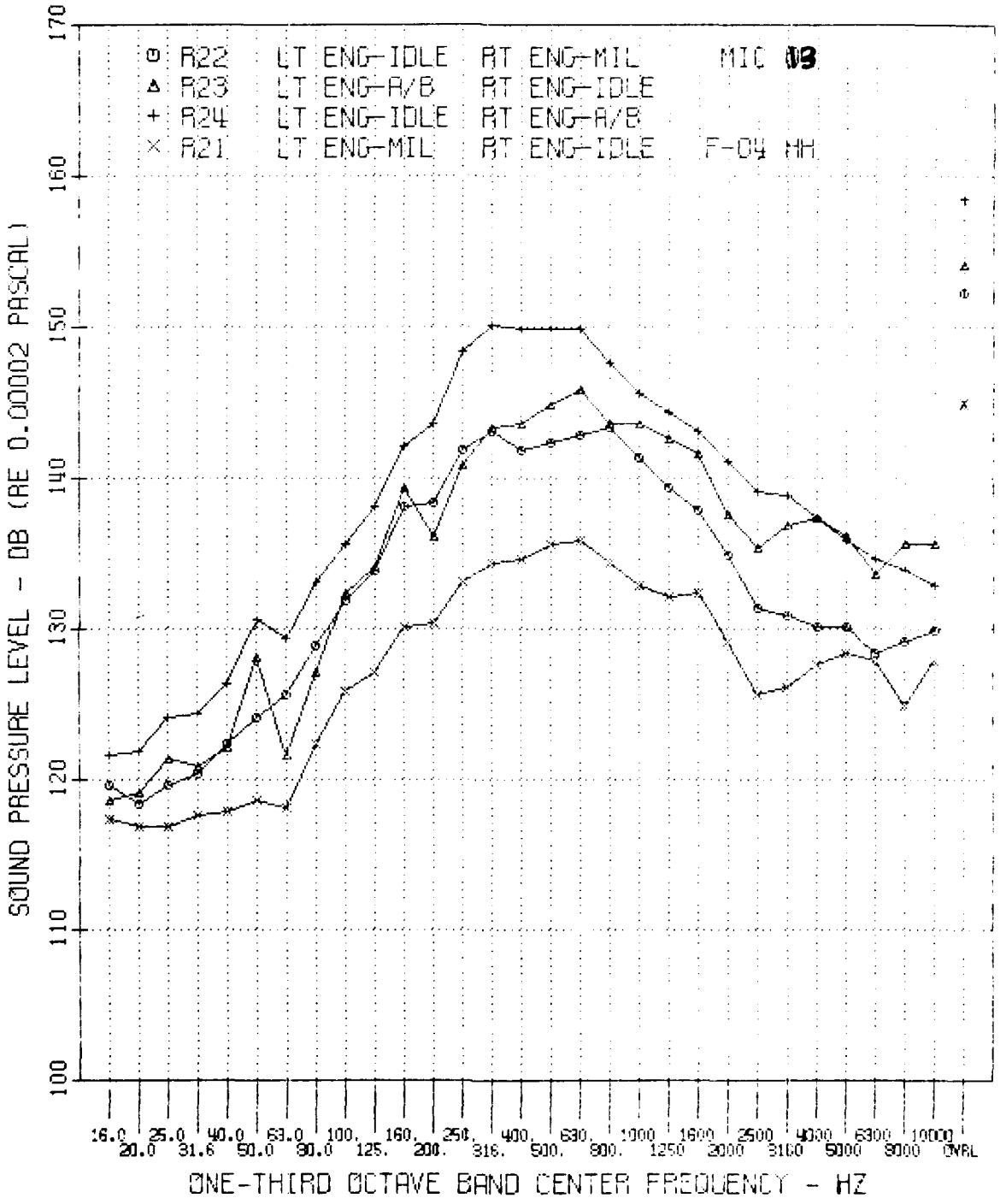

FIGURE B13 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 13.

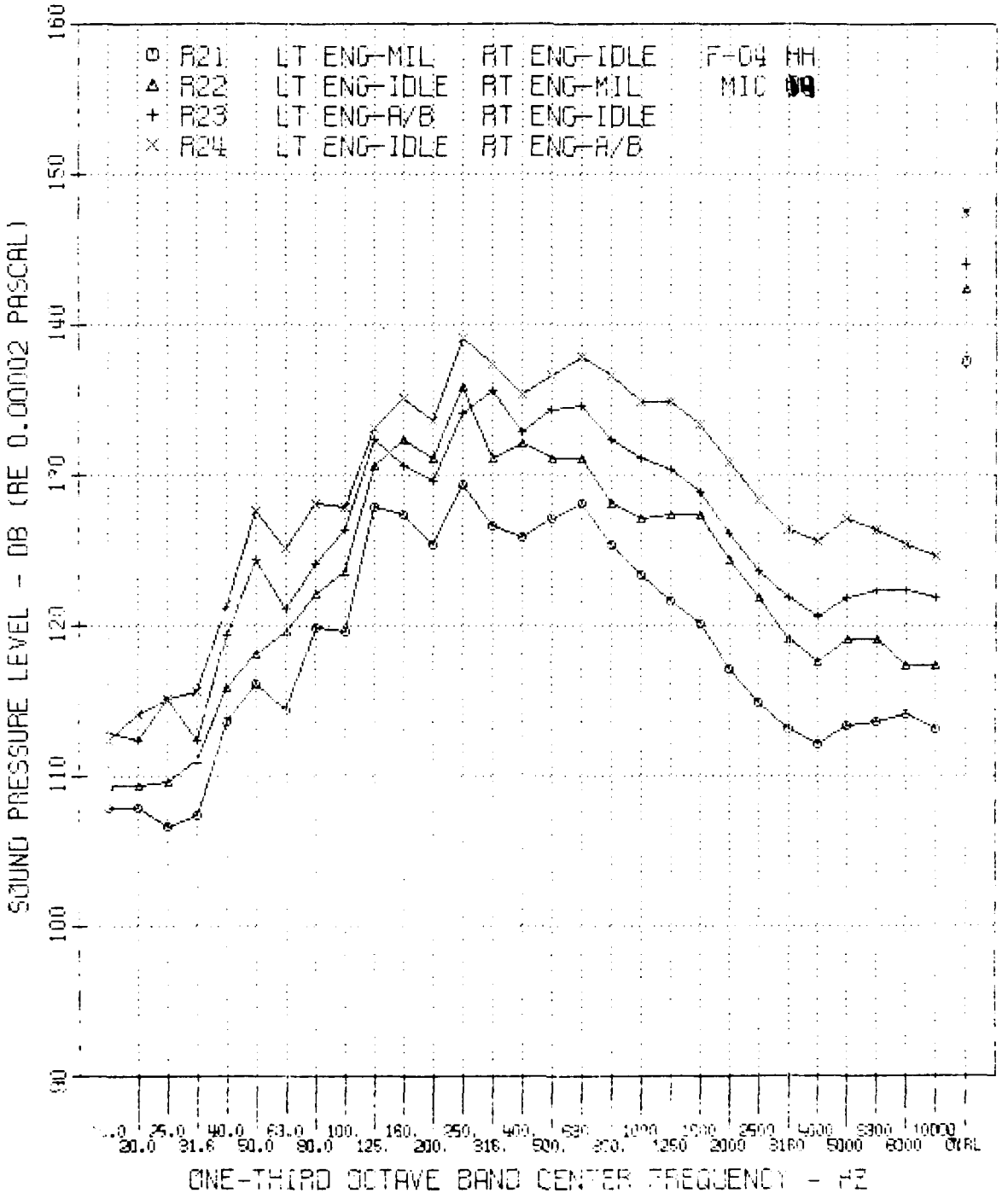

FIGURE B14 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 14.

GRAPH 18

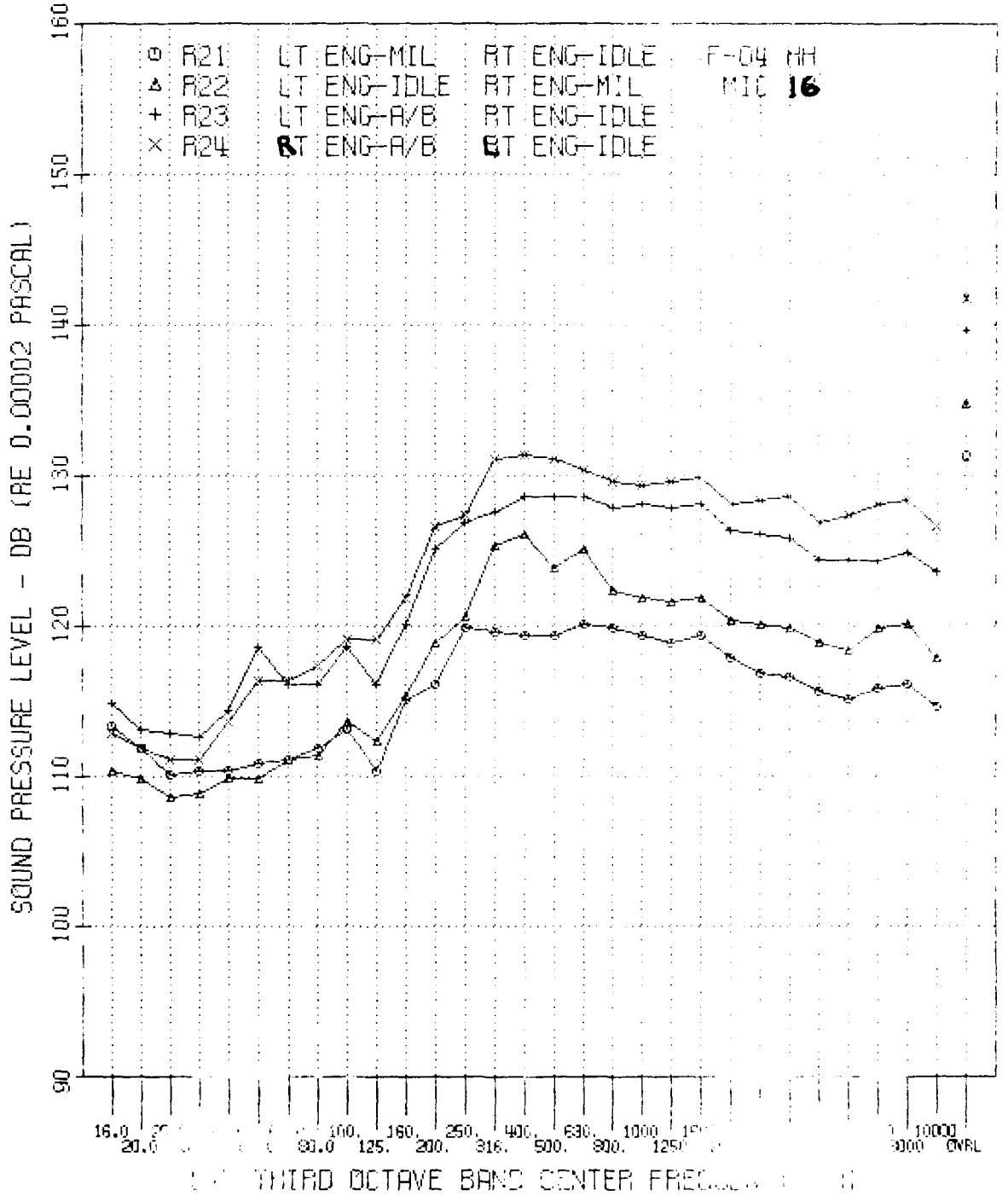

FIGURE B15 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 16.

GRAPH 19

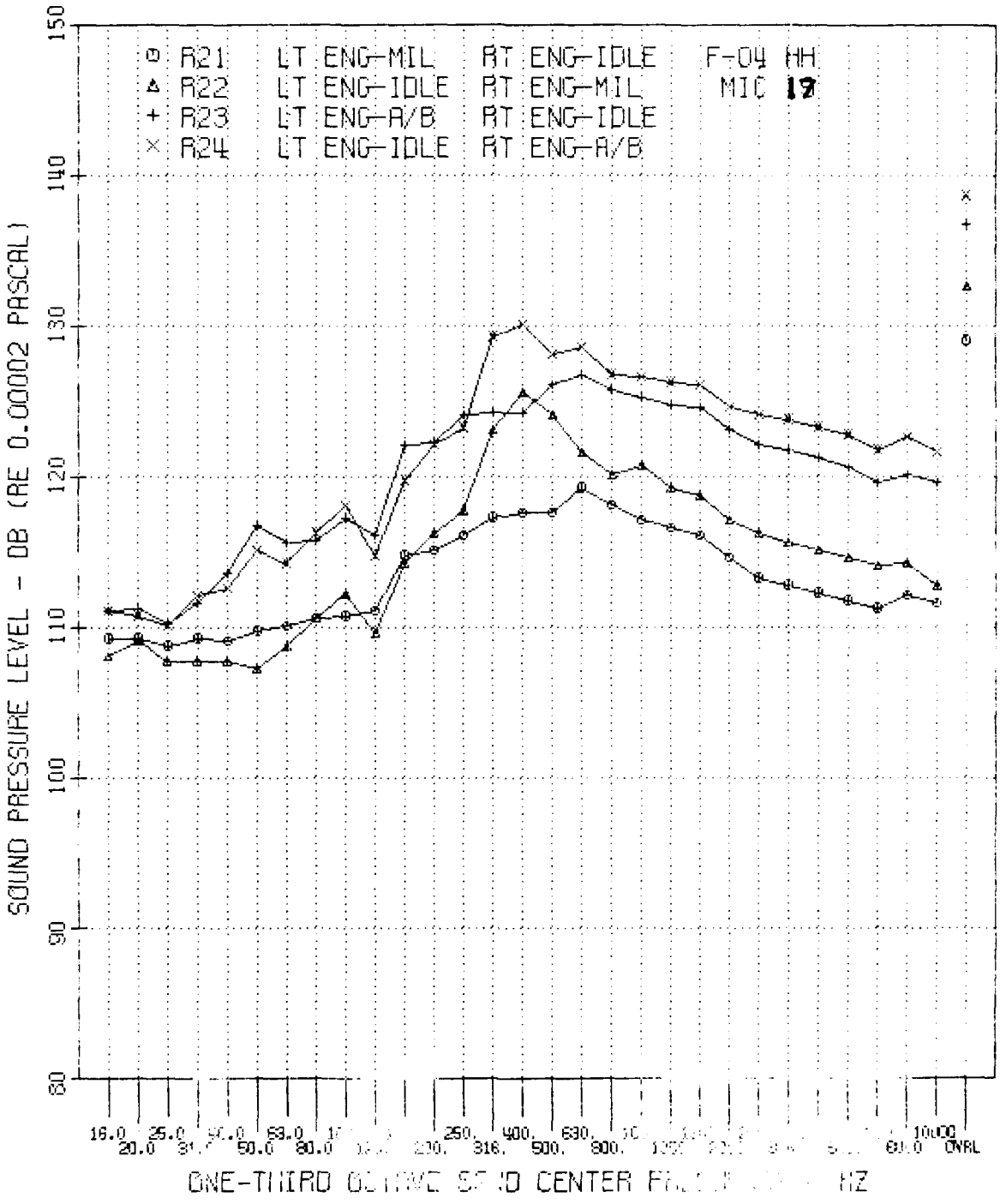

FIGURE B16 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 17.

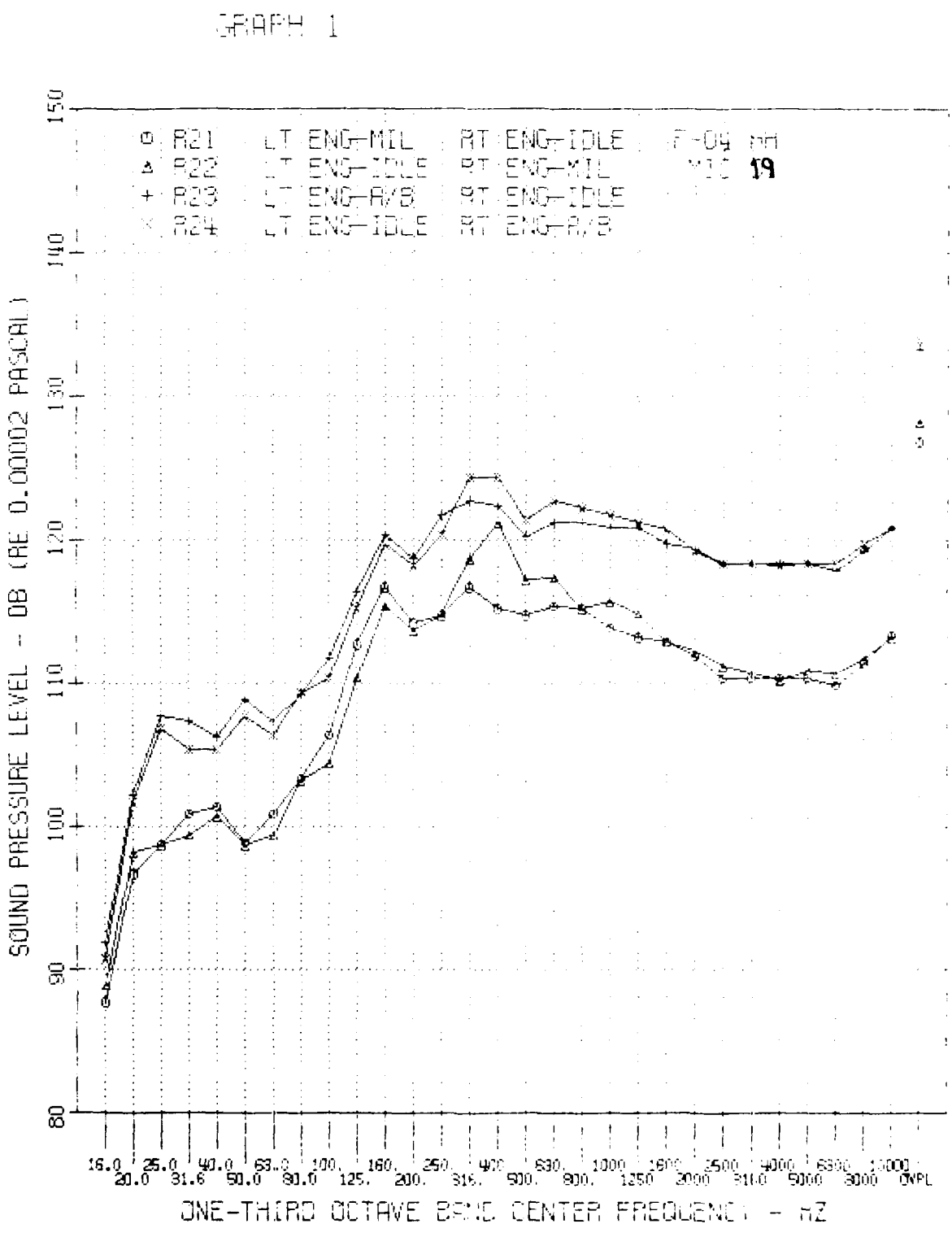

FIGURE B17 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 19.

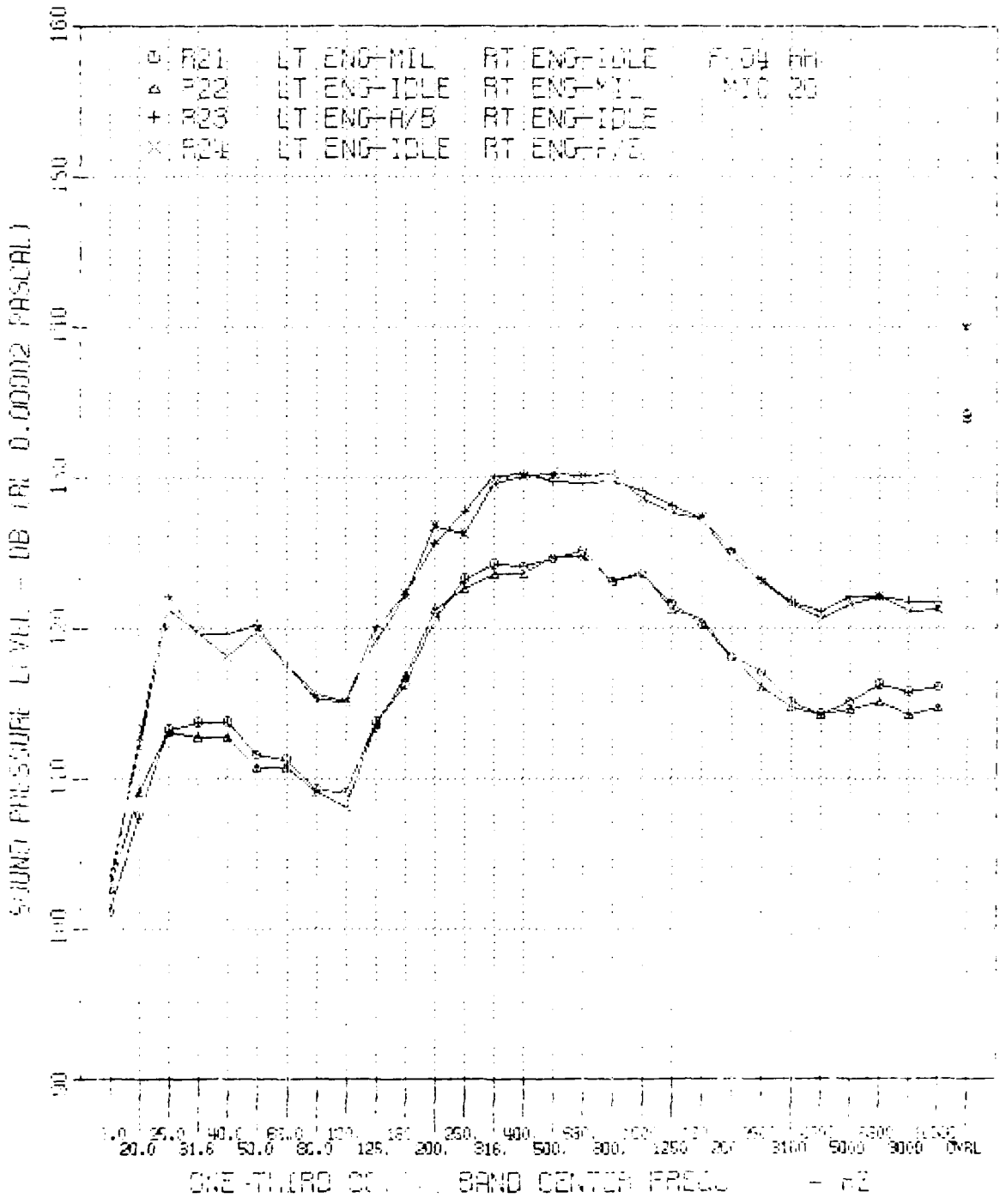

FIGURE B18 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 20.

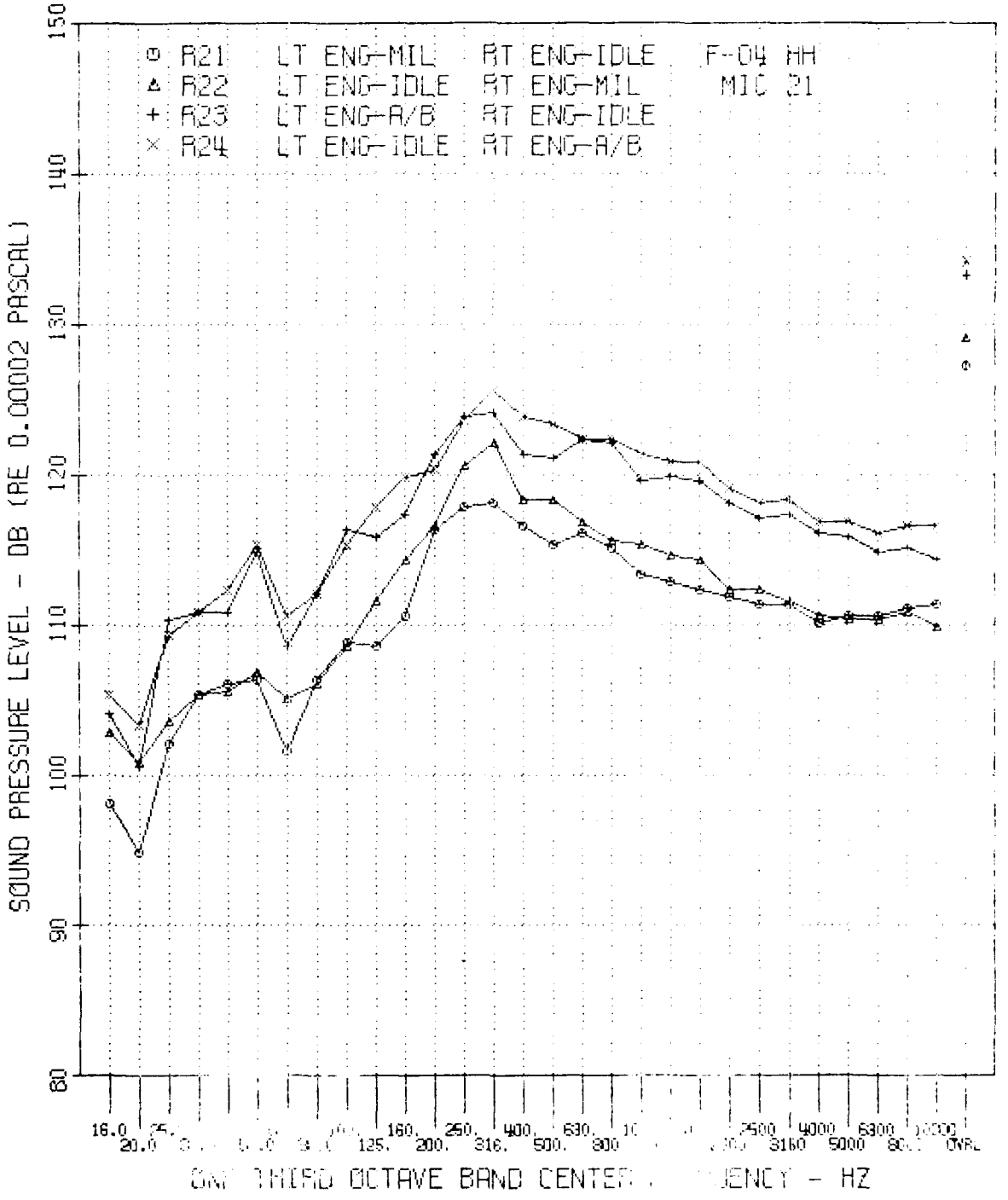

FIGURE B19 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 21.

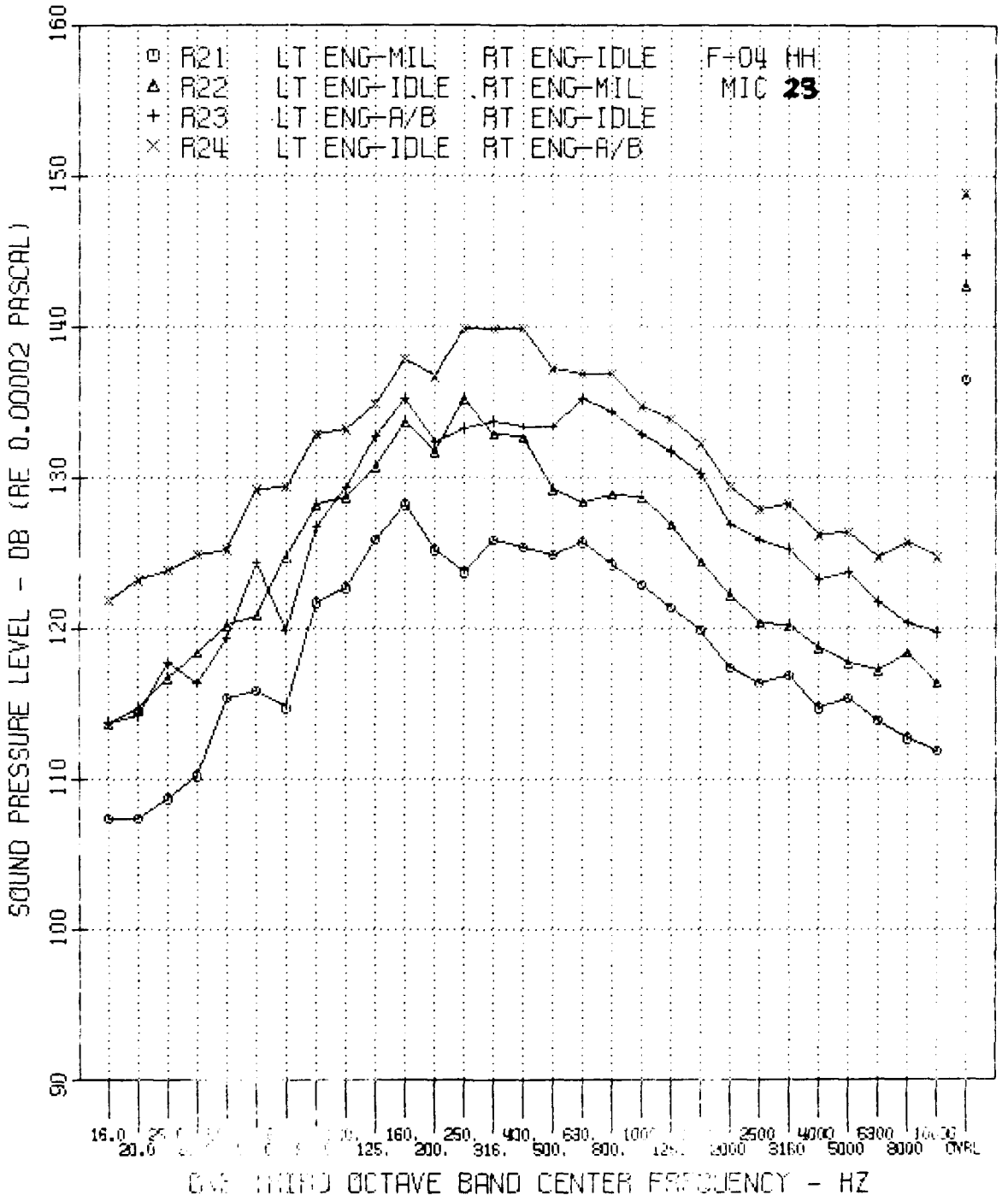

FIGURE B20 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 23.

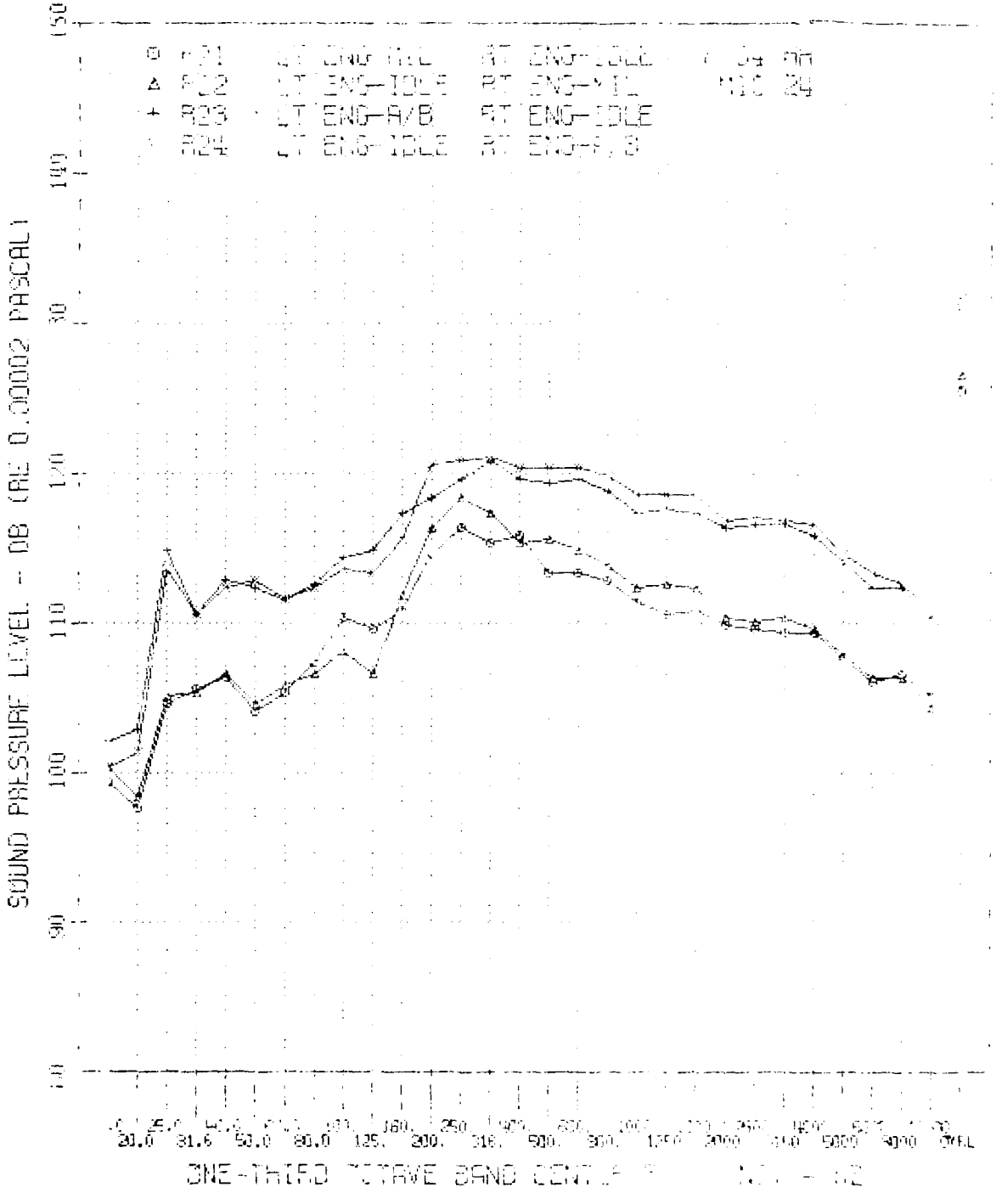

FIGURE B21 One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 24.

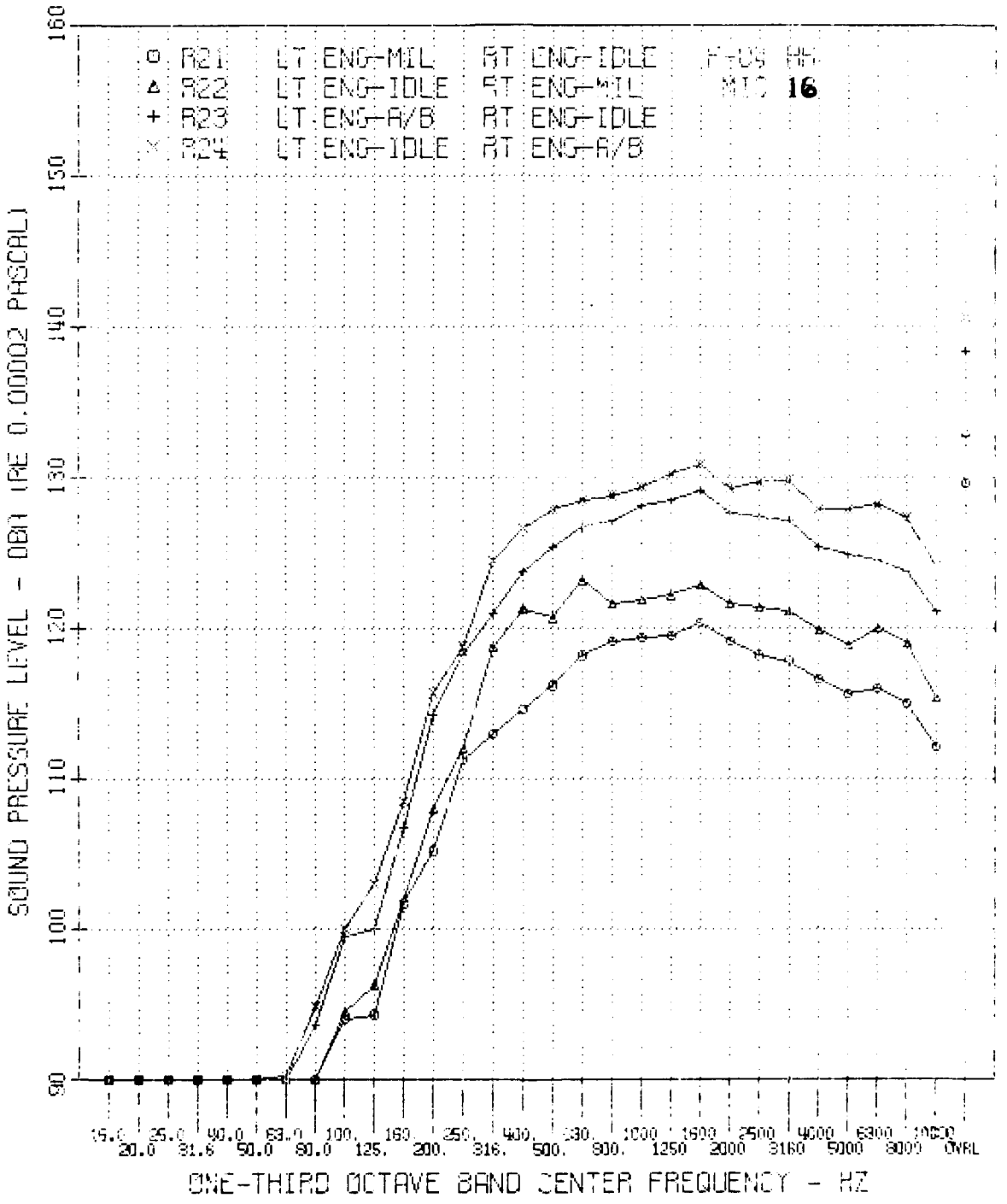

FIGURE B22 A-Weighted One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 16.

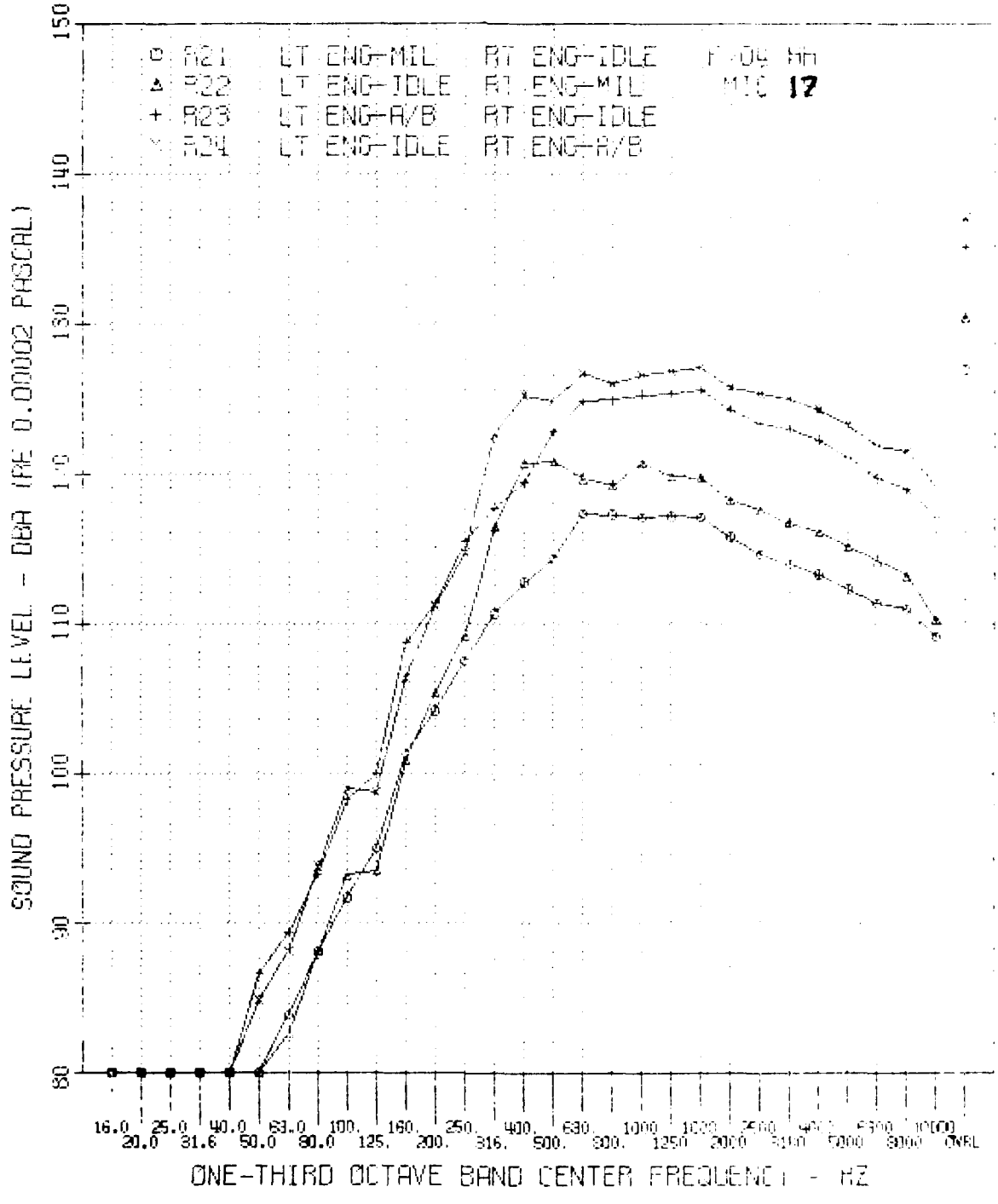

FIGURE B23 A-Weighted One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 17.

GRAPH 1

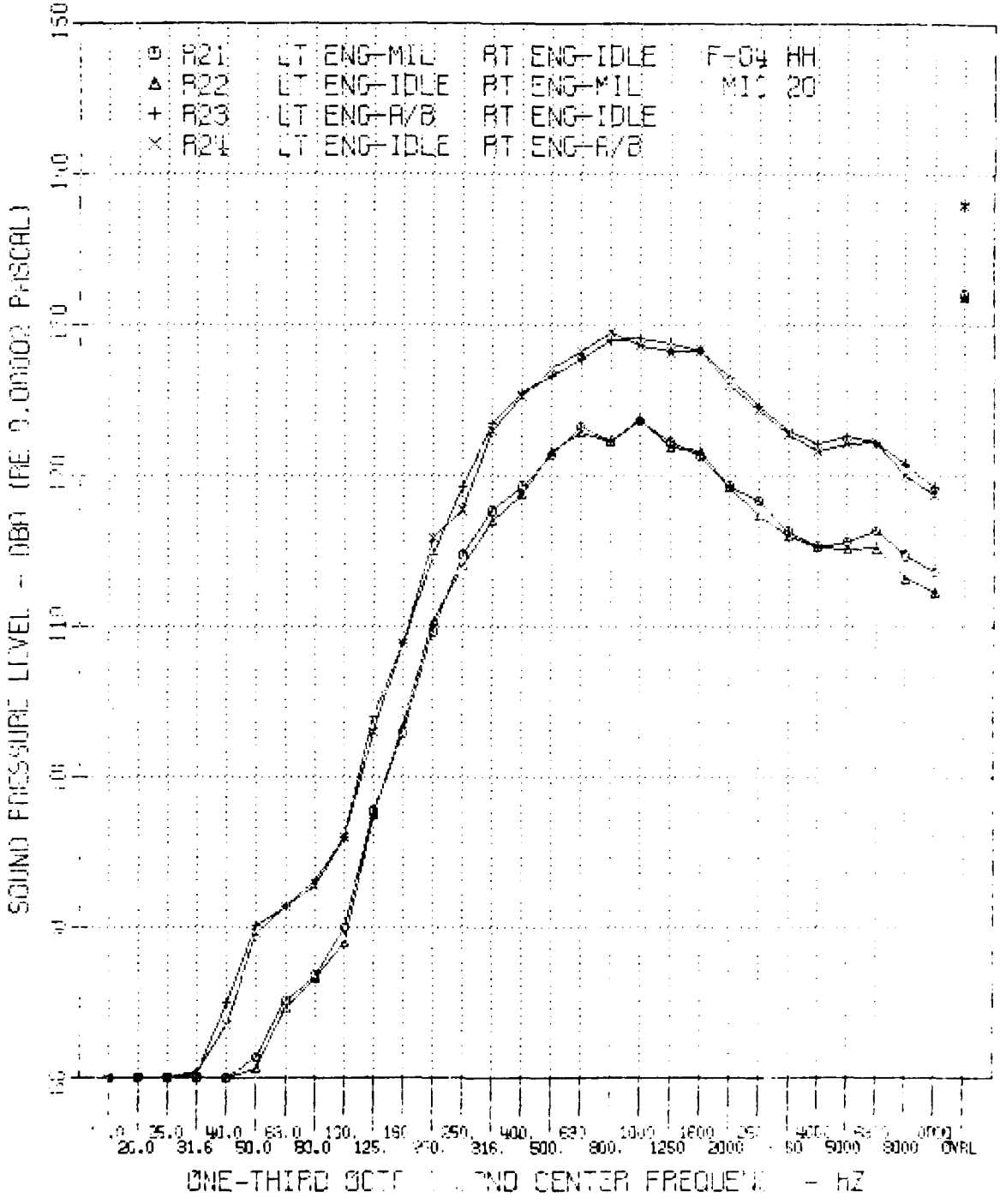

FIGURE B24 A-Weighted One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 20.

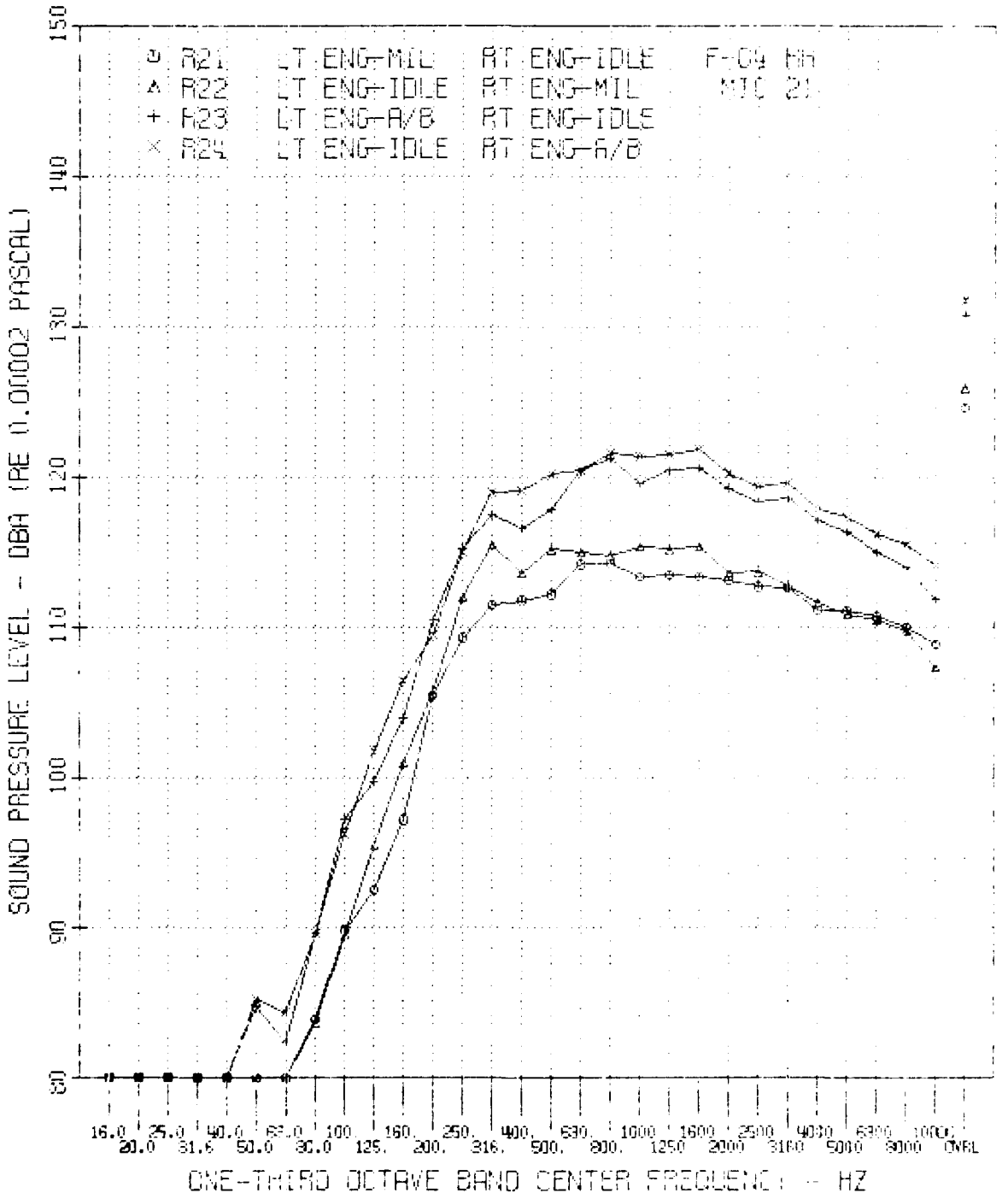

FIGURE B25 A-Weighted One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 21.

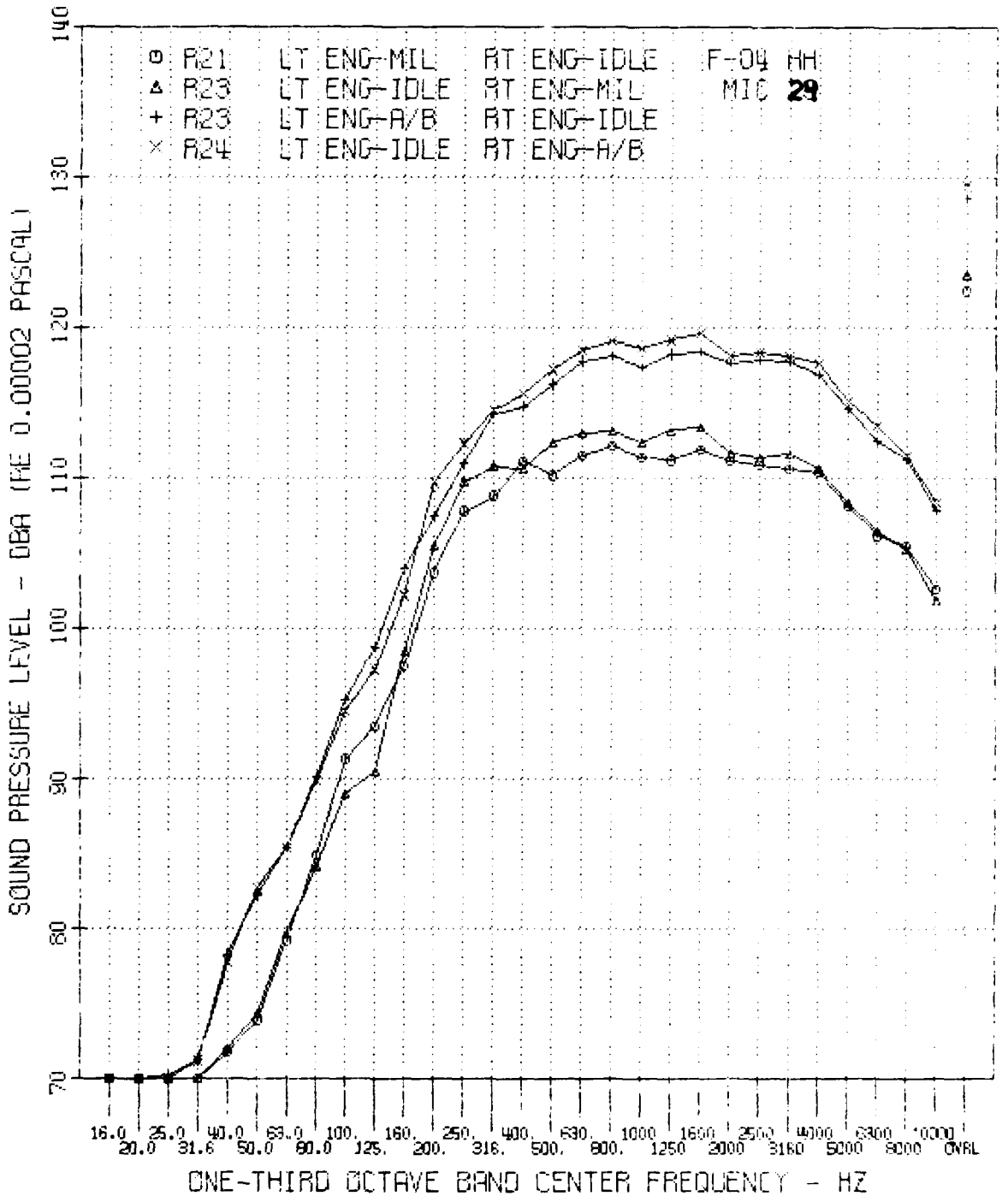

FIGURE B26 A-Weighted One-Third Octave Band Spectra for F-4E Aircraft Installed in Hush House for Record Numbers 21, 22, 23, 24 - Microphone 24.

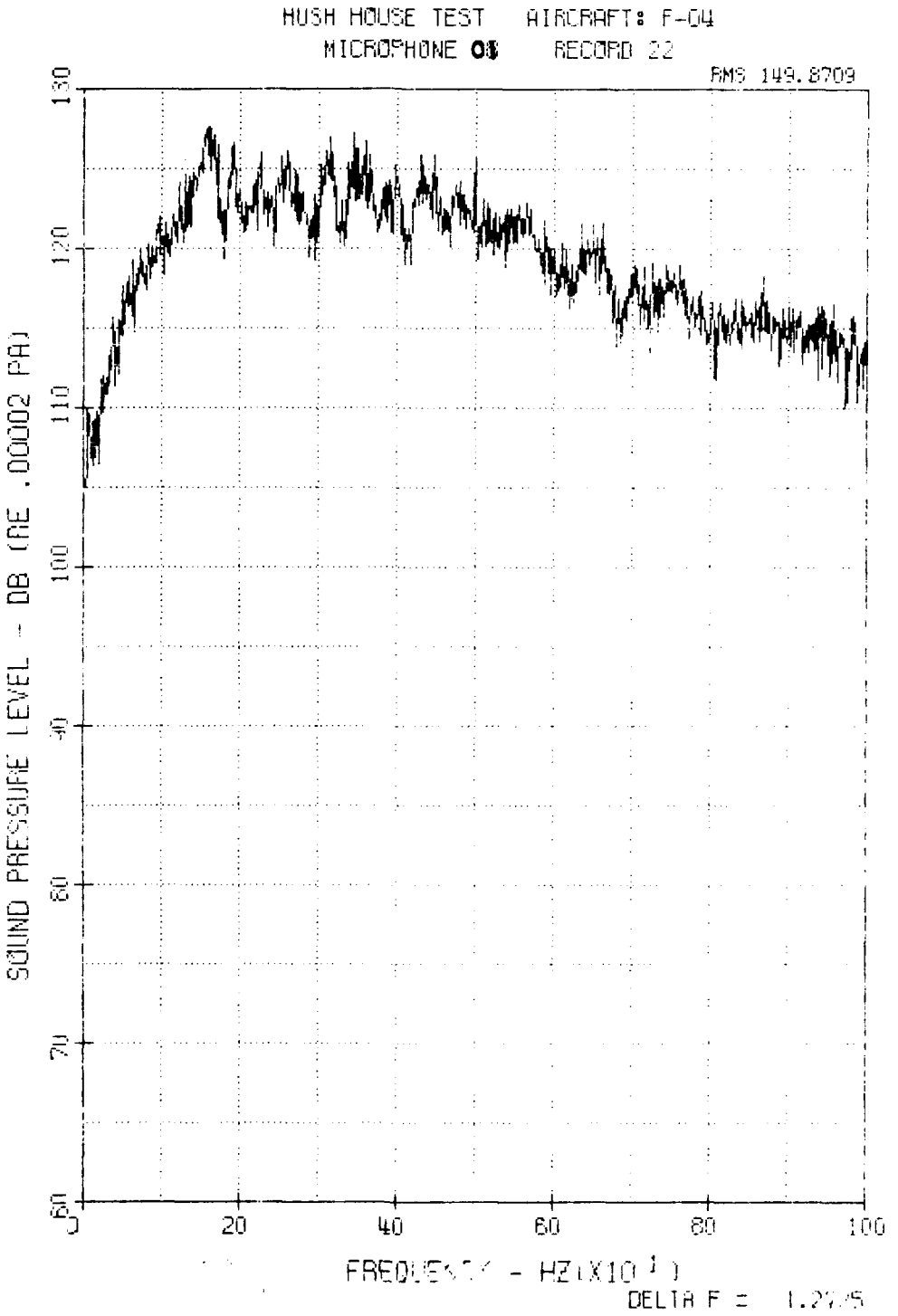

FIGURE B27 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 22 - Microphone 1.

11
6

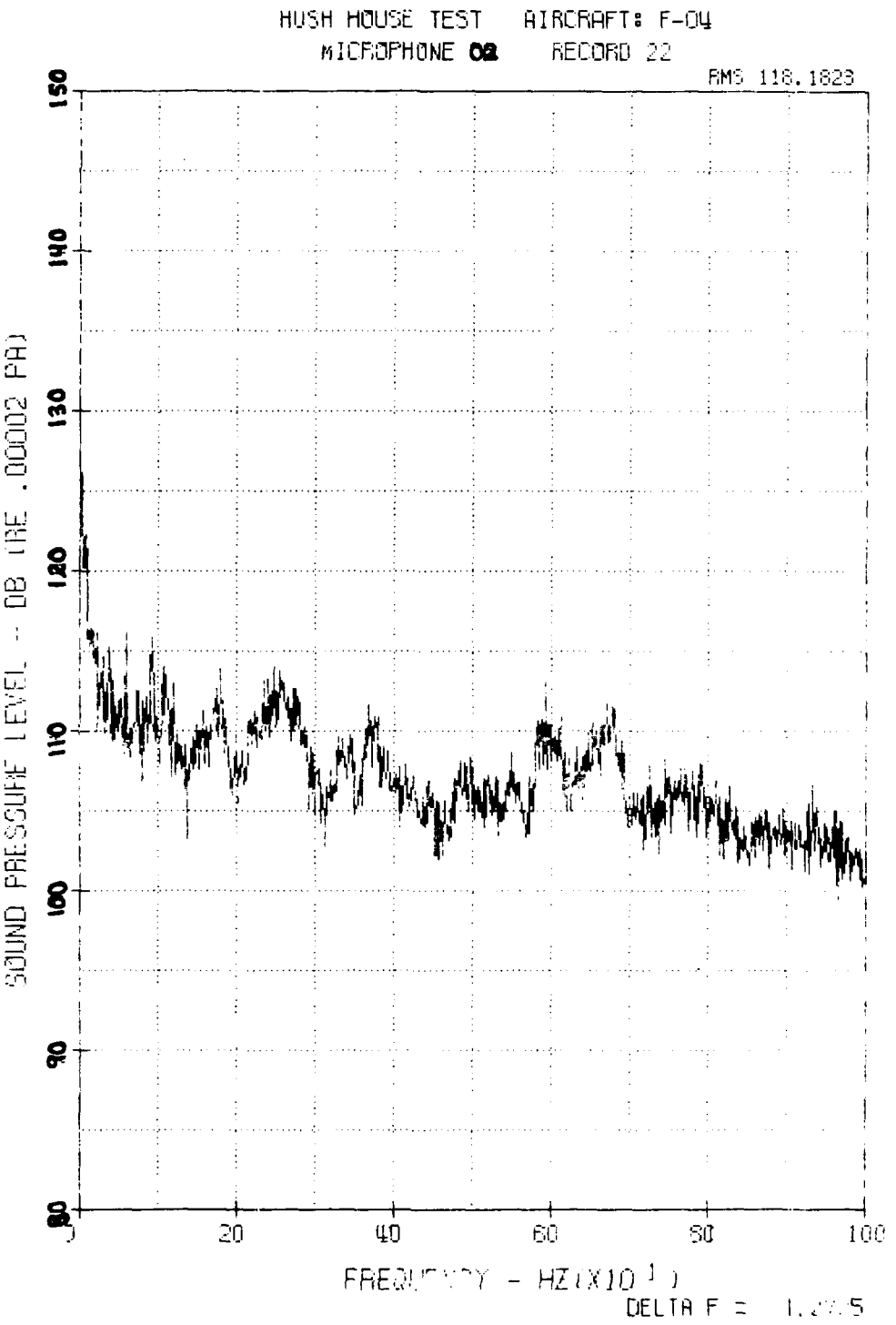

FIGURE B28 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 22 - Microphone 2.

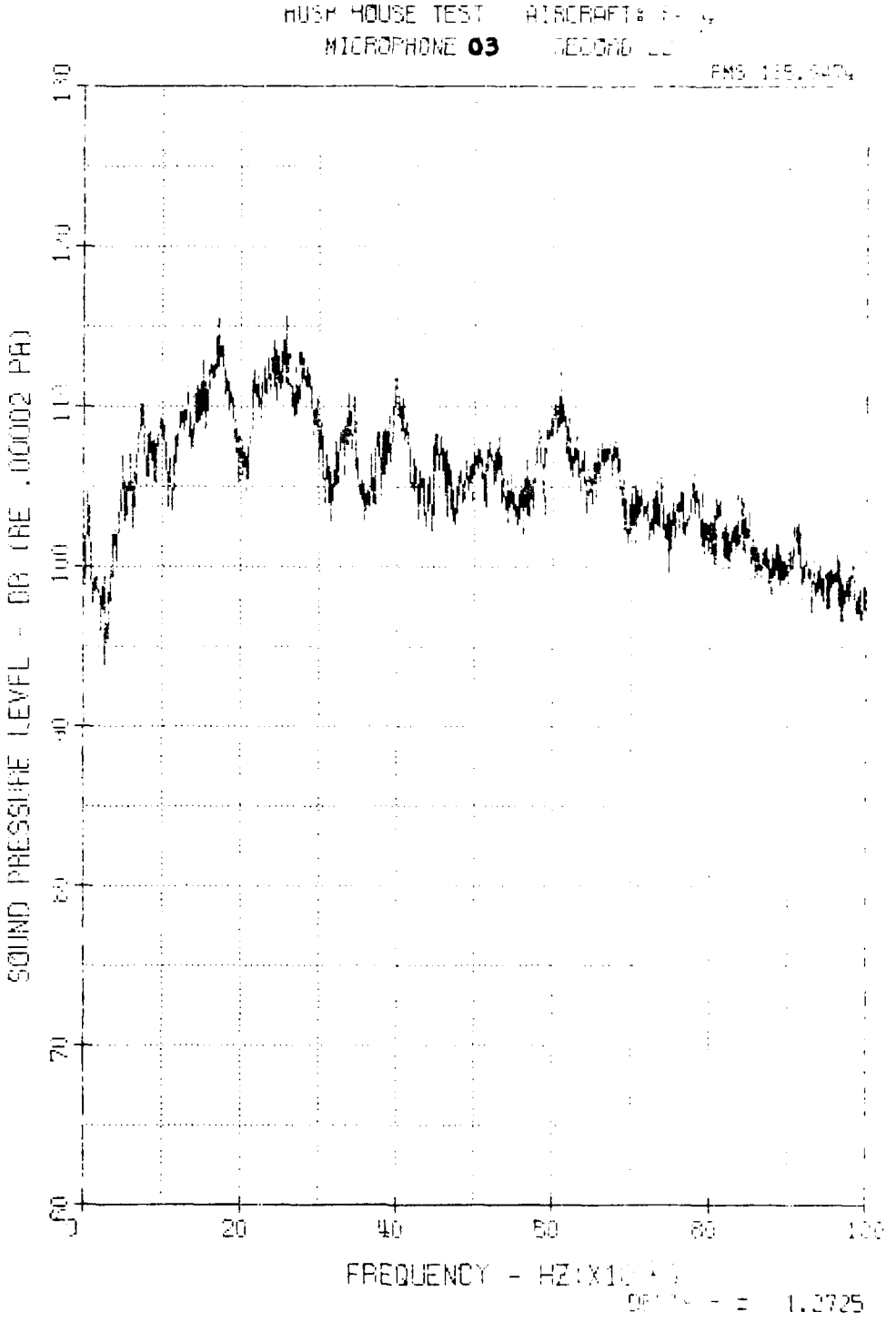

FIGURE B29 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 22 - Microphone 3.

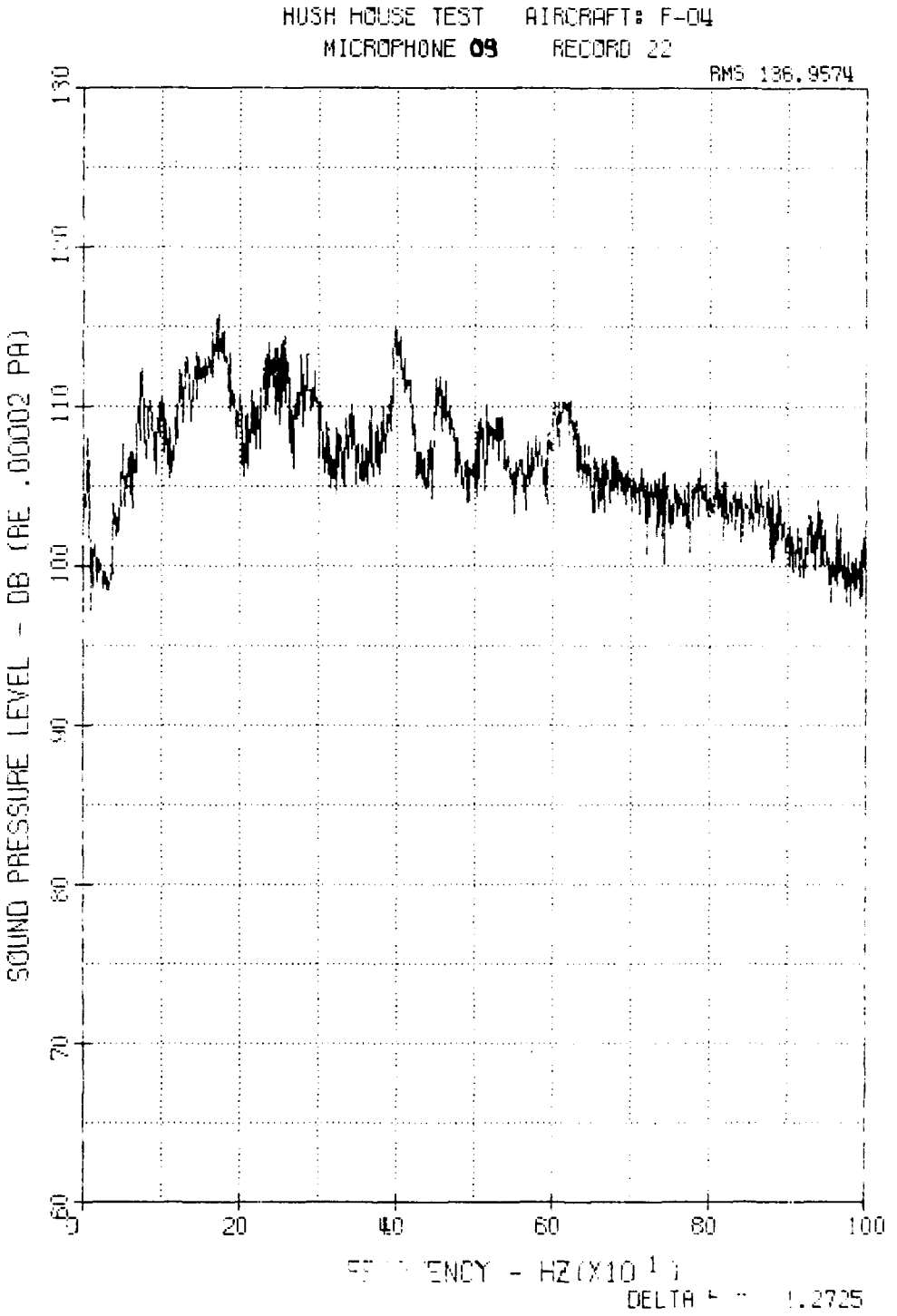

FIGURE B30 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 22 - Microphone 4.

10
22

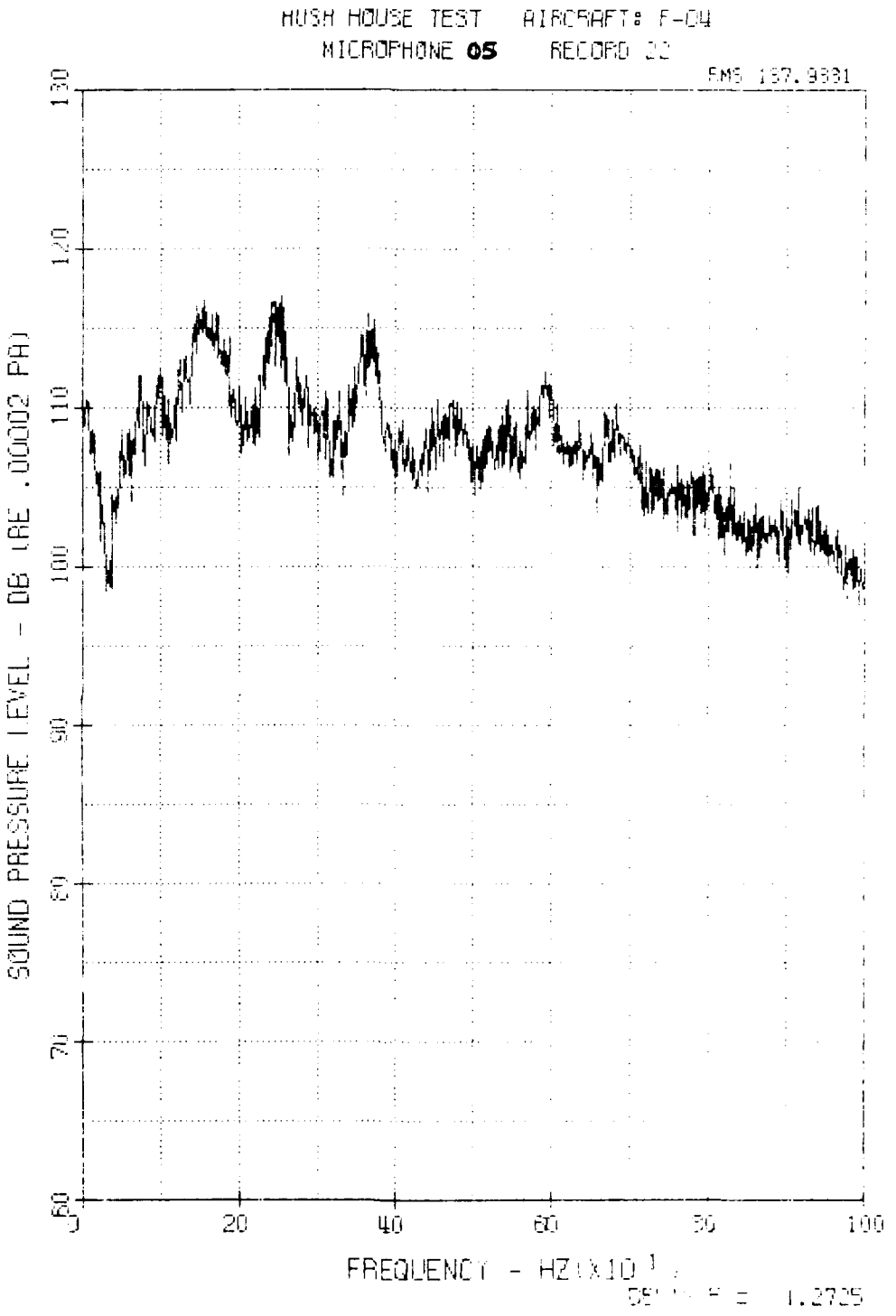

FIGURE B31 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 22 - Microphone 5.

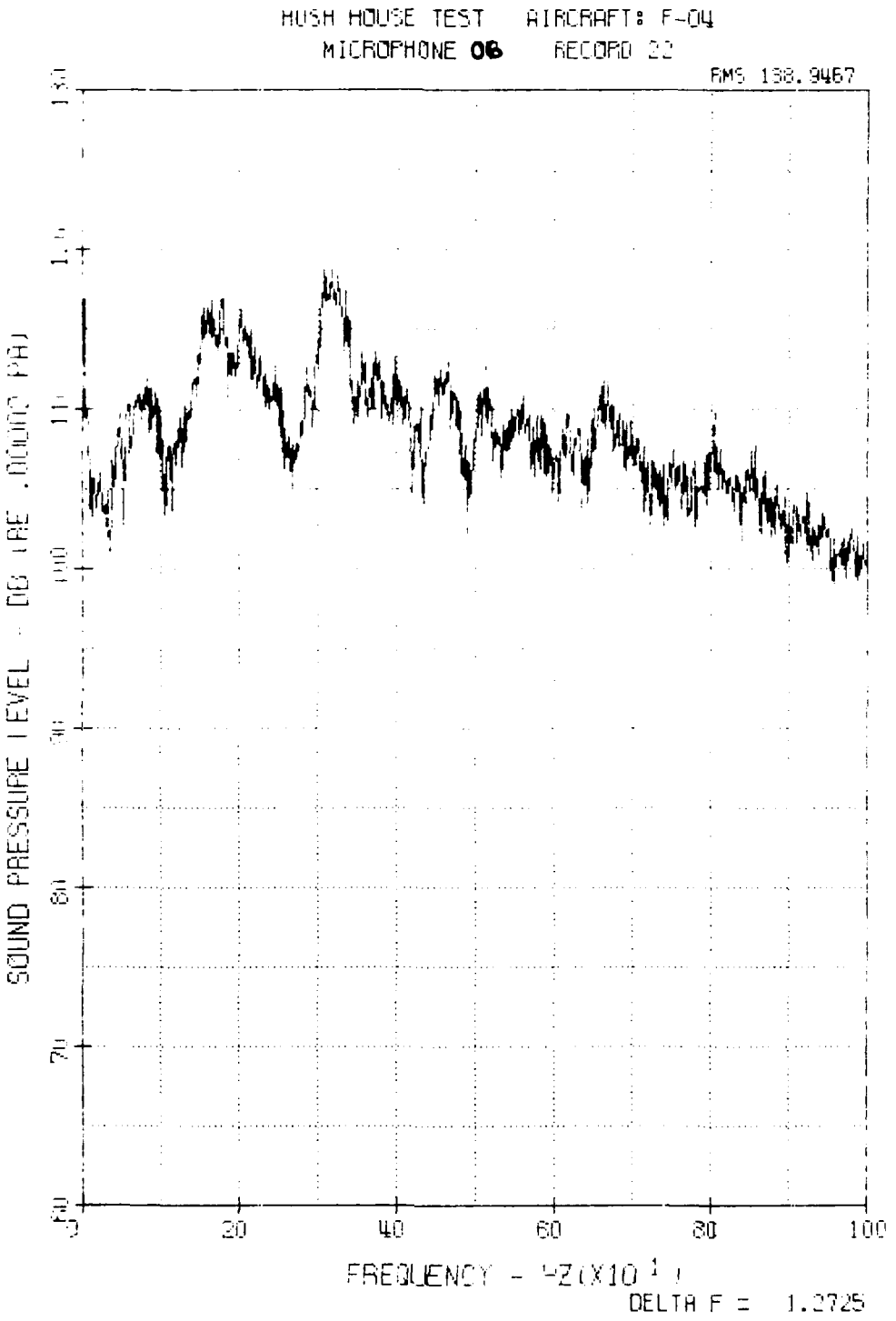

FIGURE B32 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 22 - Microphone 6.

10
24

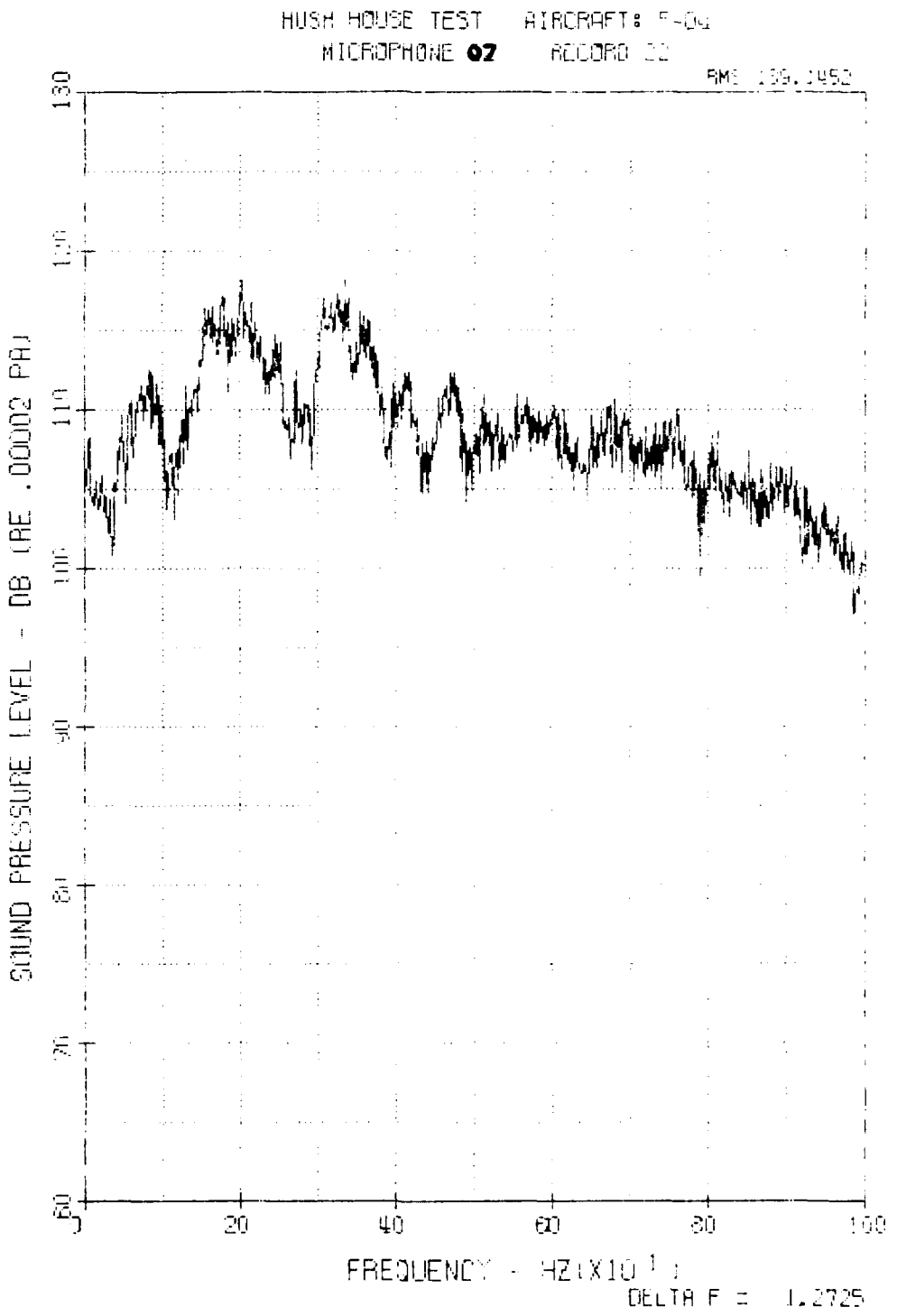

FIGURE B33 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 22 - Microphone 7.

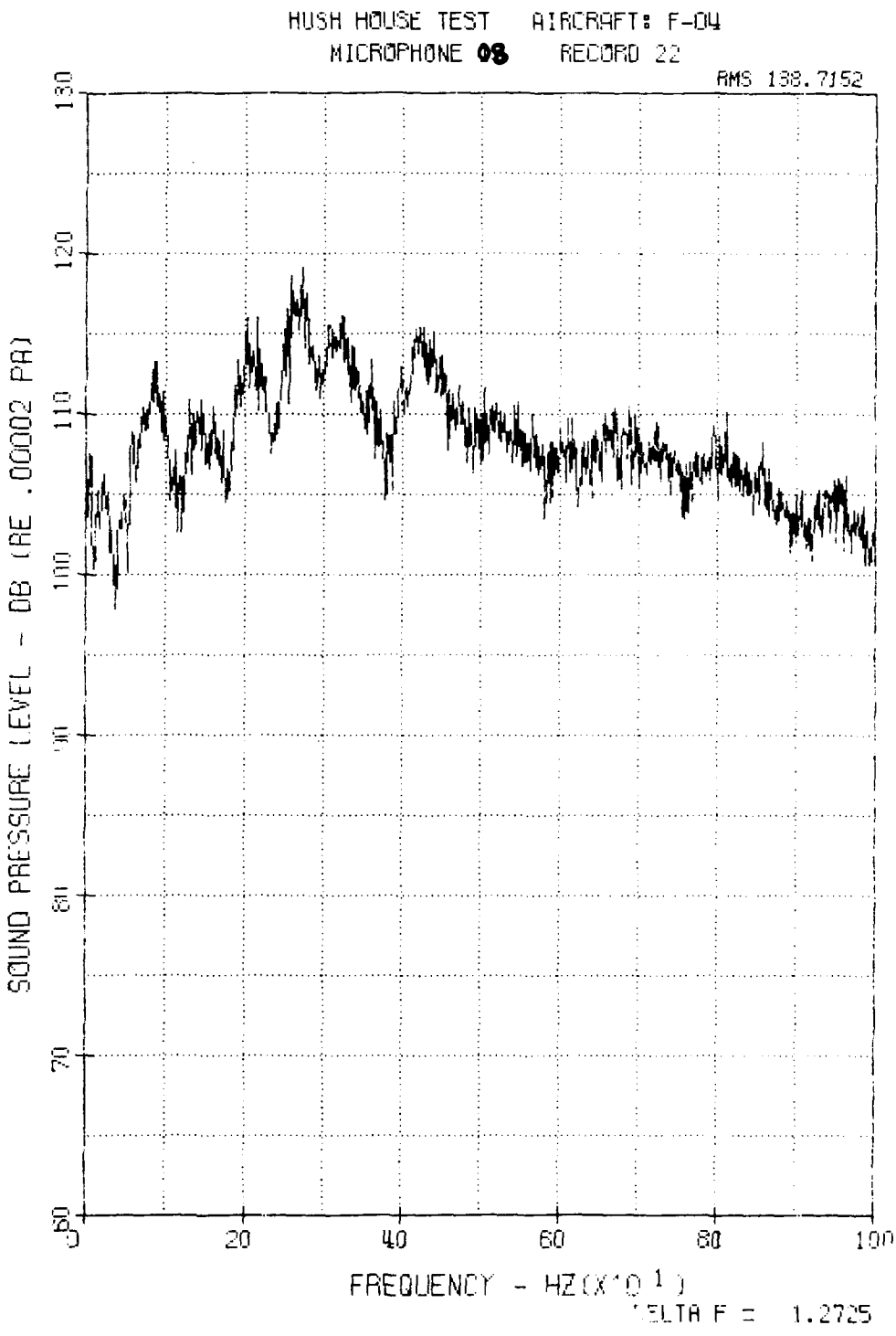

FIGURE B34 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 22 - Microphone 8.

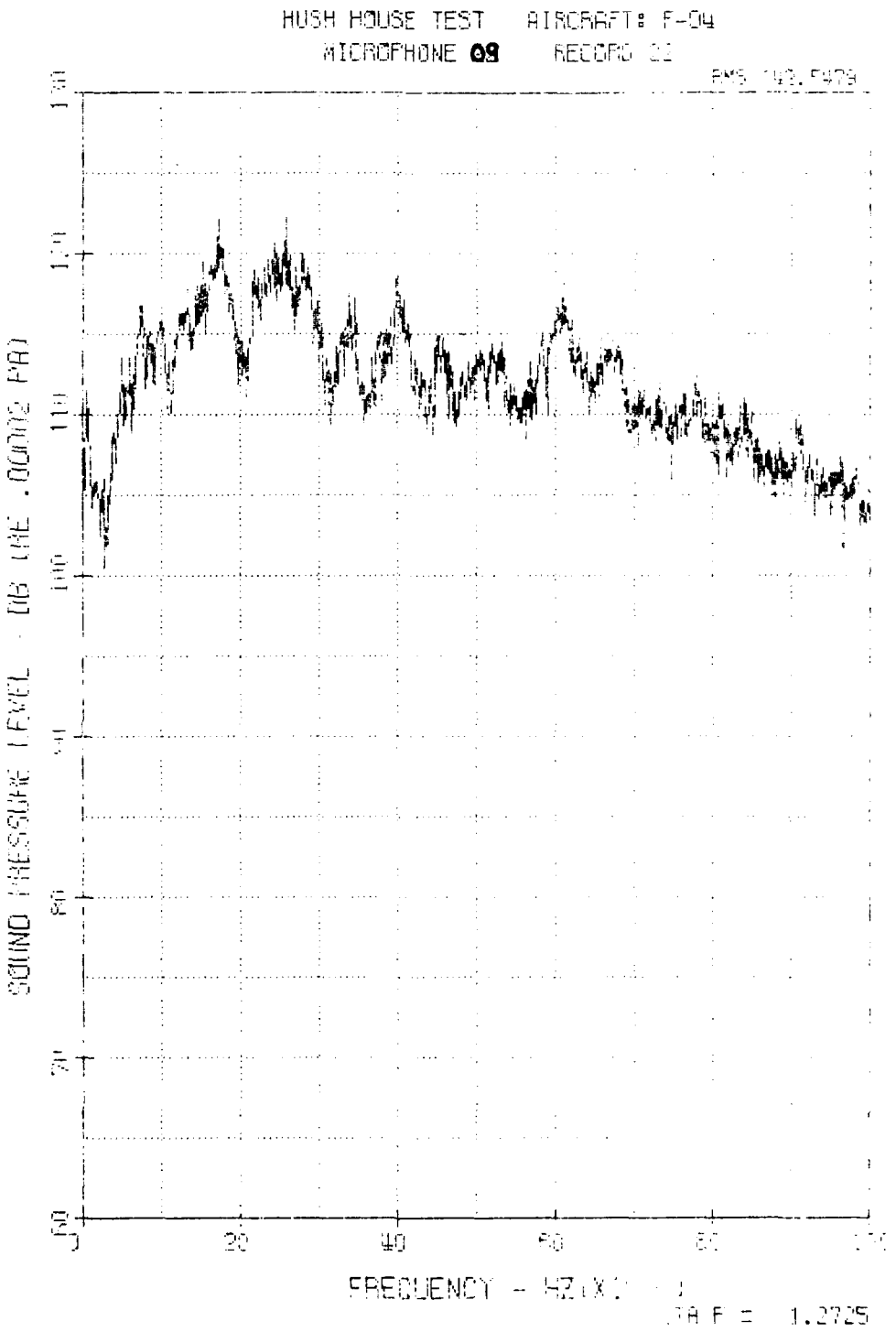

FIGURE B35 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 22 - Microphone 9.

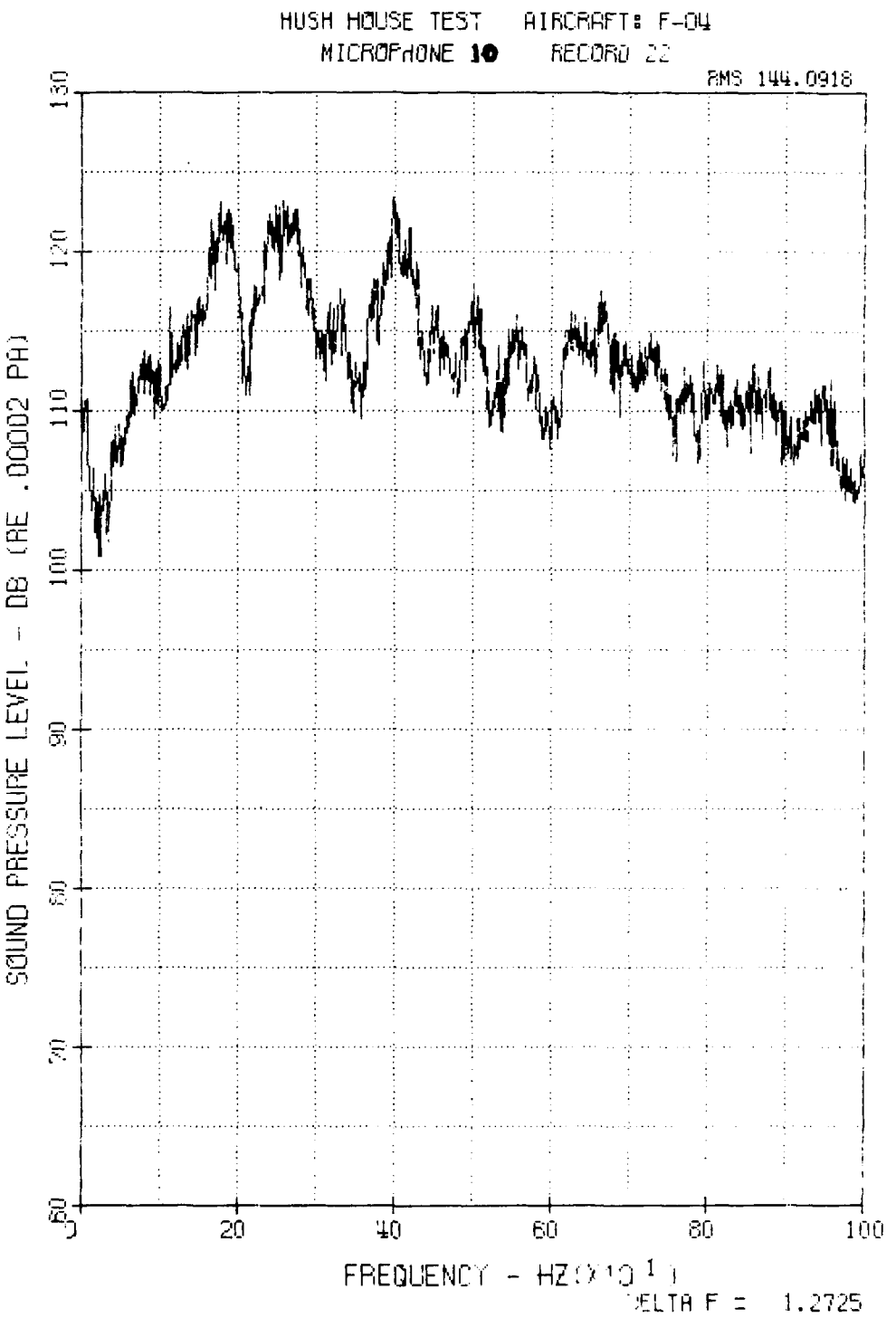

FIGURE B36 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 22 - Microphone 10.

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15

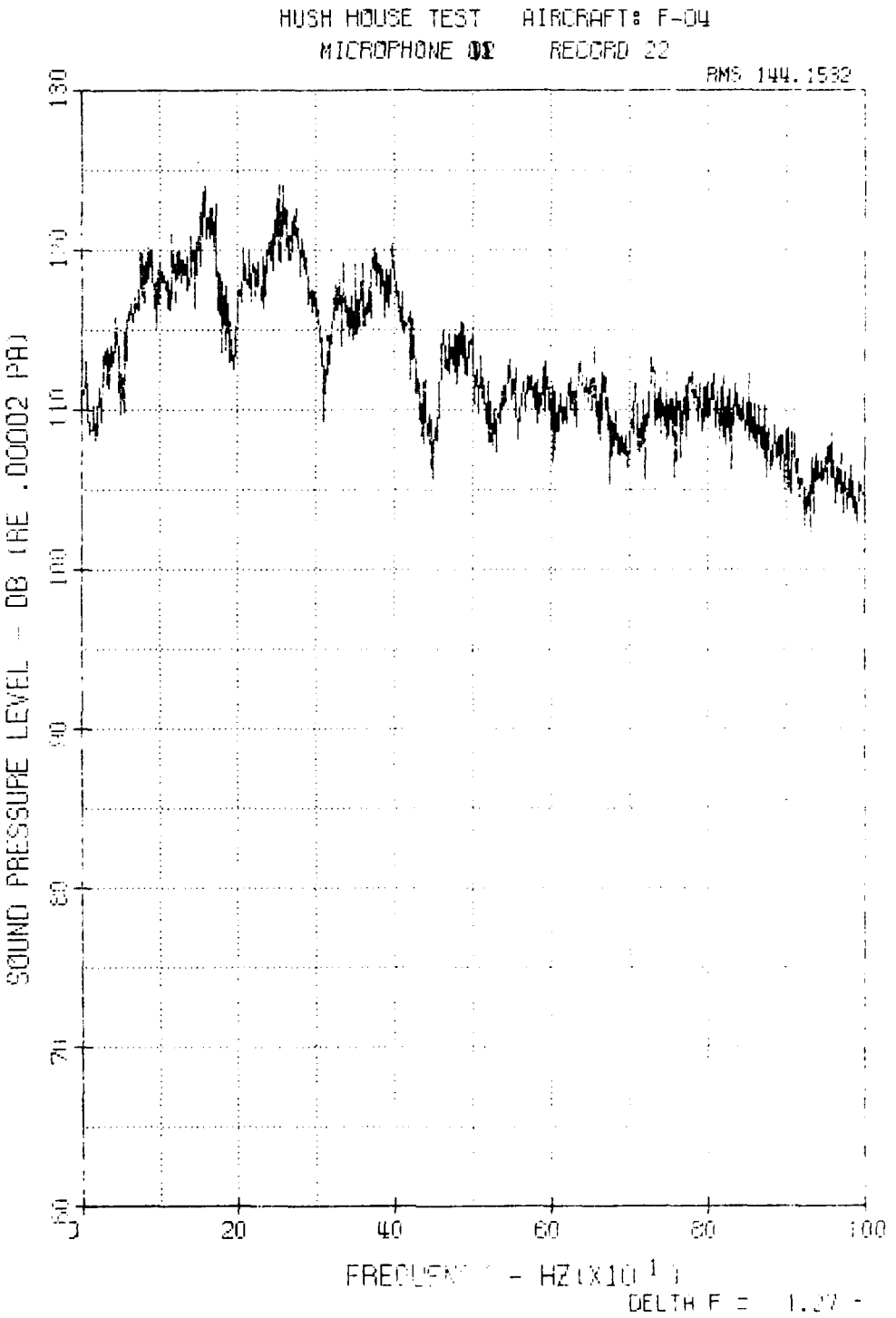


FIGURE B37 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 22 - Microphone 11.

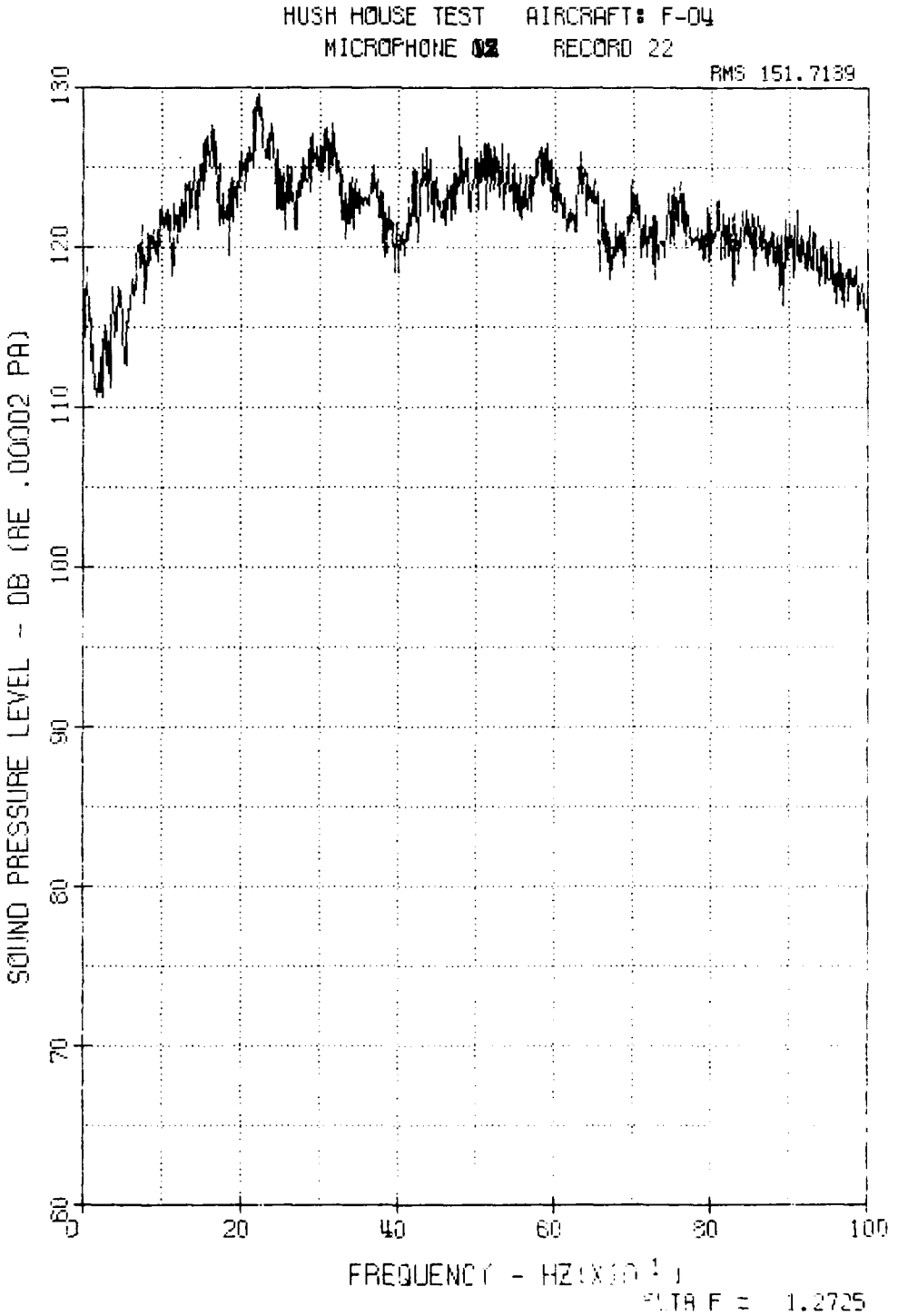


FIGURE B38 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 22 - Microphone 12.

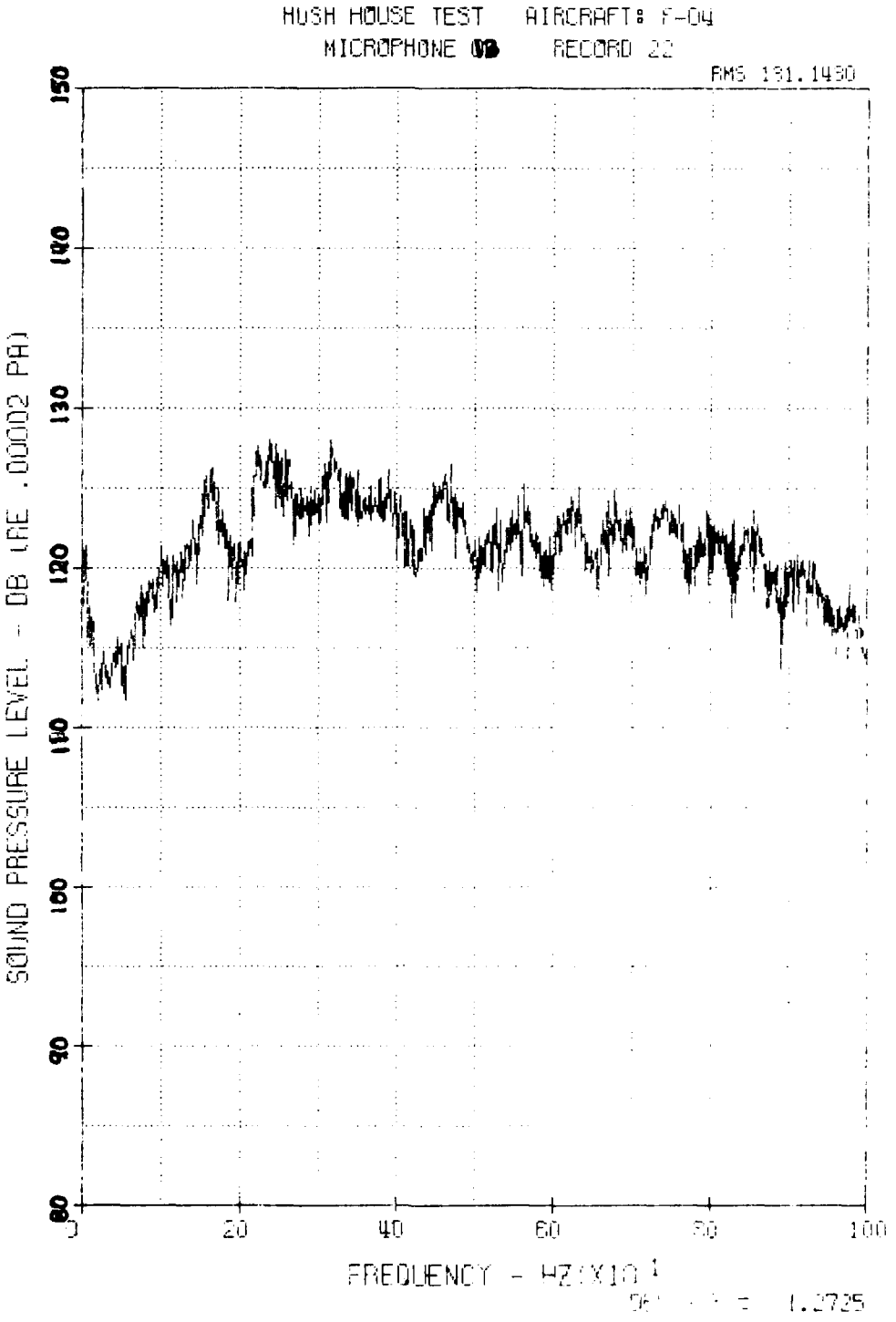


FIGURE B39 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 22 - Microphone 13.

9
21

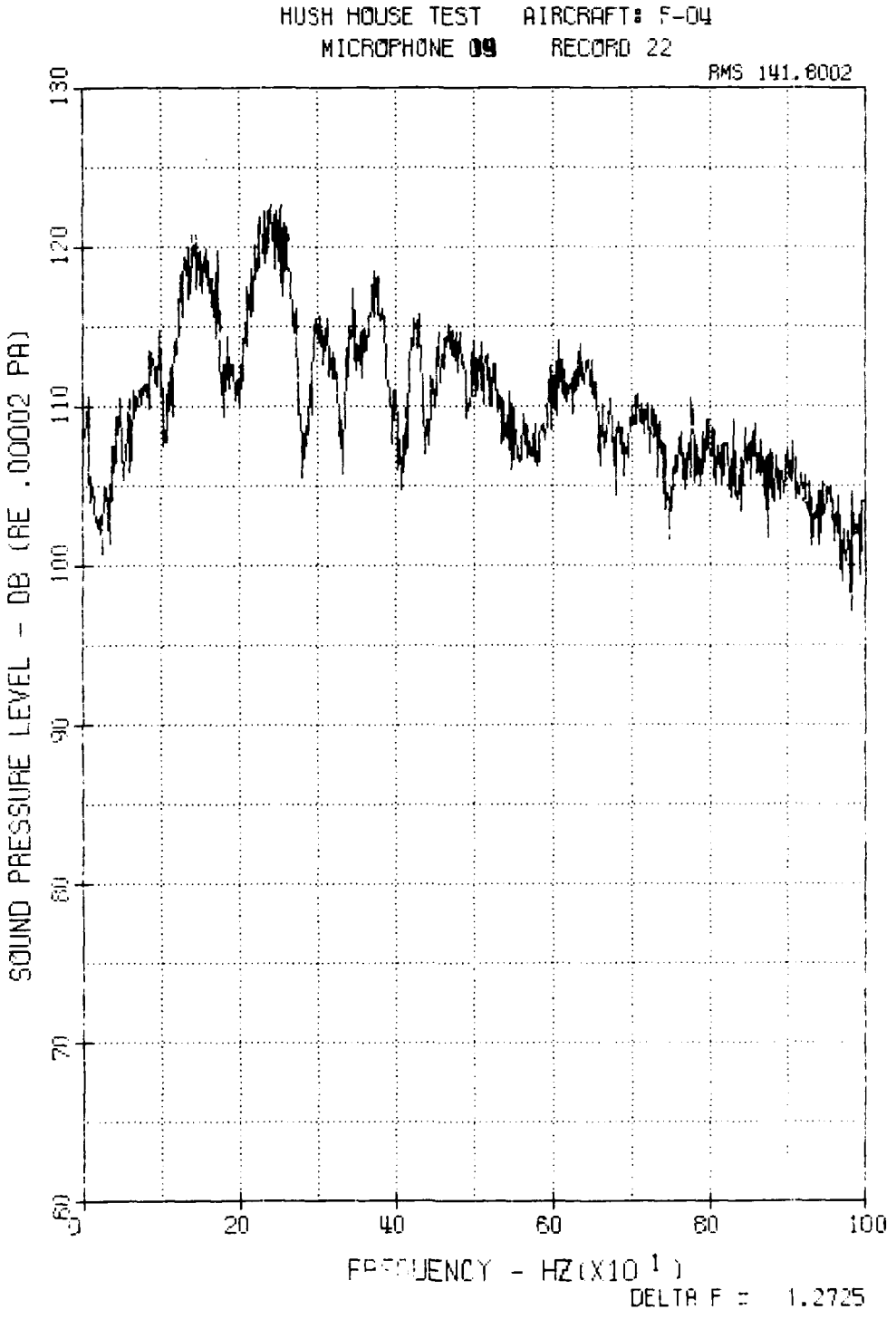


FIGURE B40 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 22 - Microphone 14.

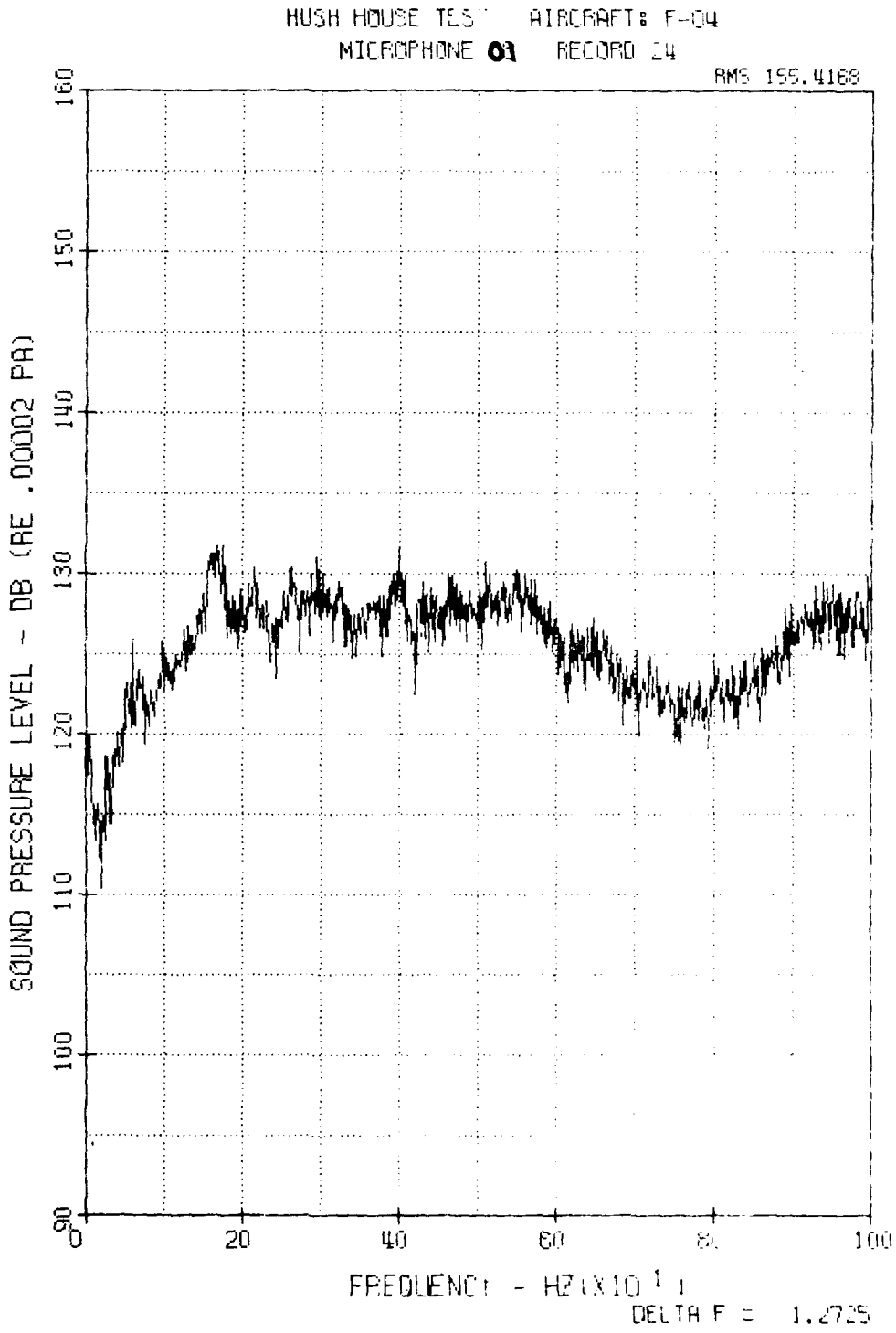


FIGURE B41 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 24 - Microphone 1.

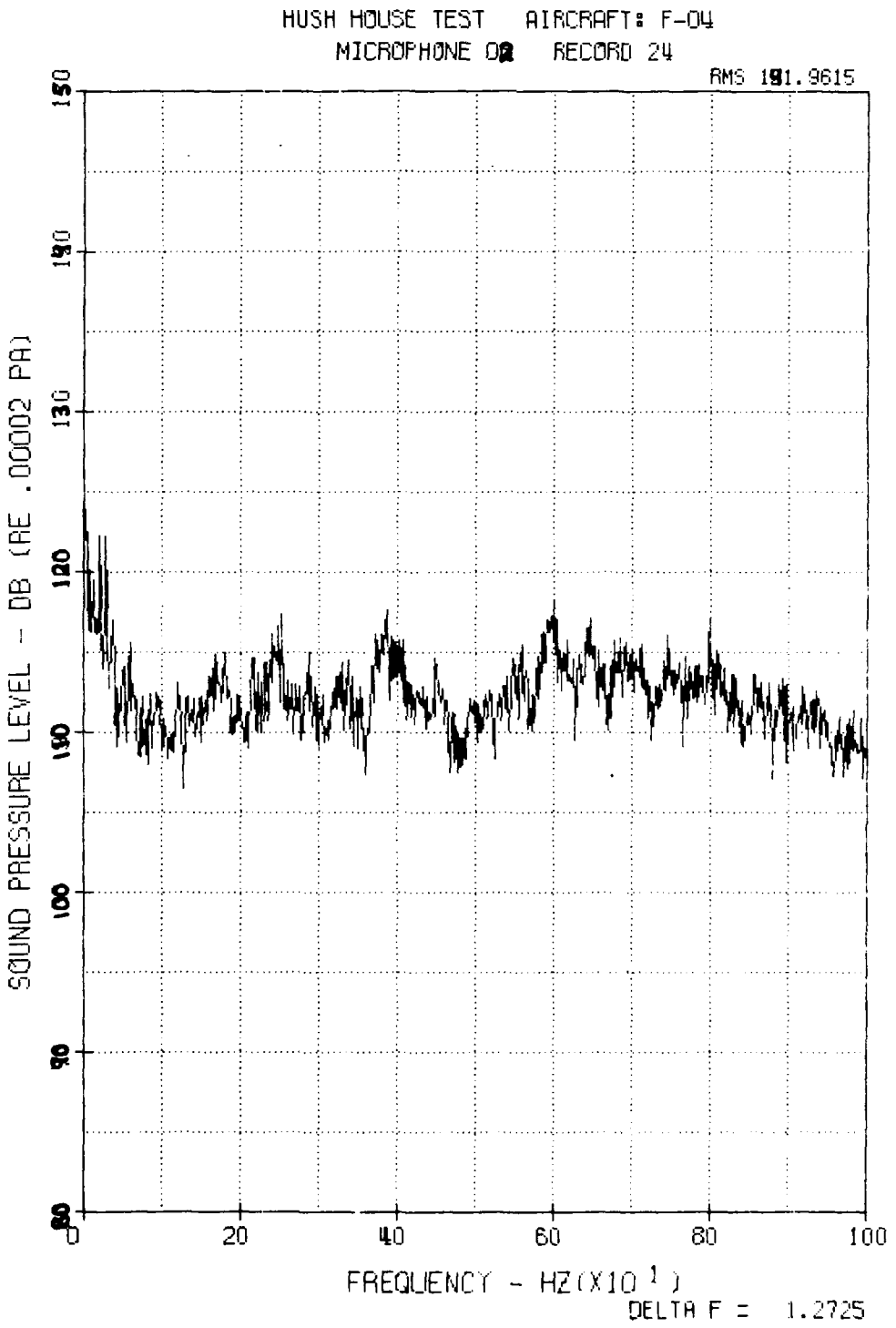


FIGURE B42 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 24 - Microphone 2.

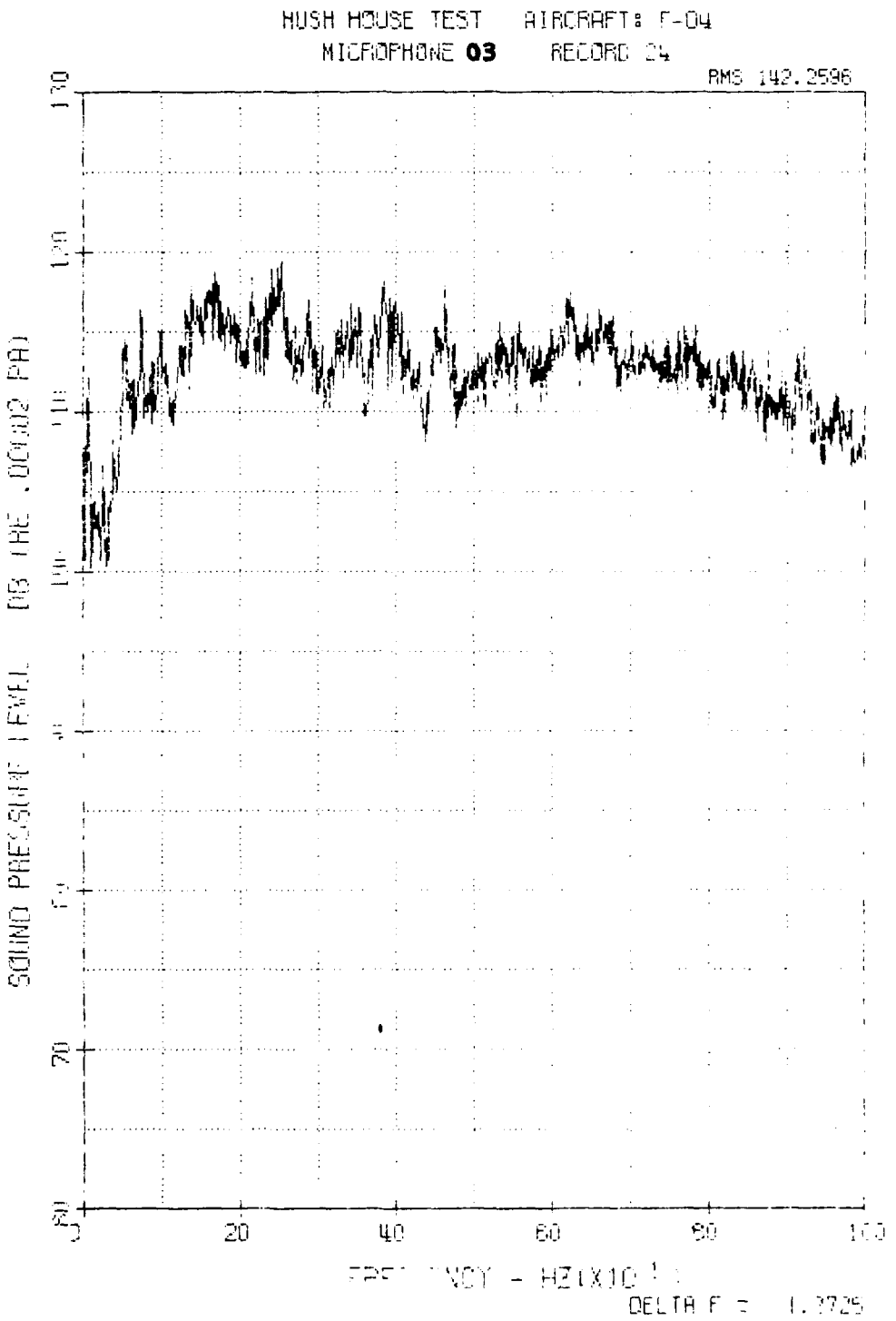


FIGURE B43 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 24 - Microphone 3.

16
39

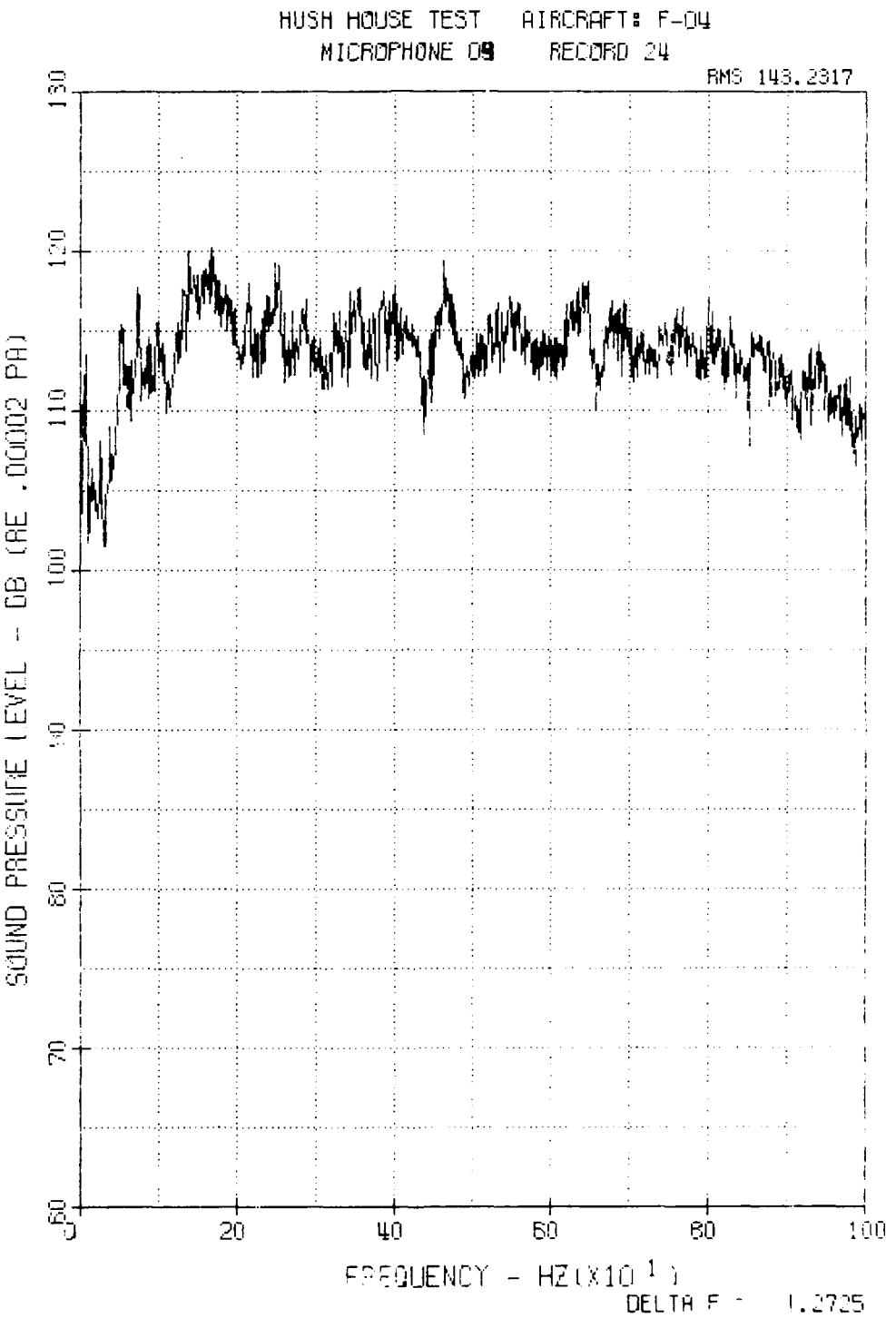


FIGURE B44 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 24 - Microphone 4.

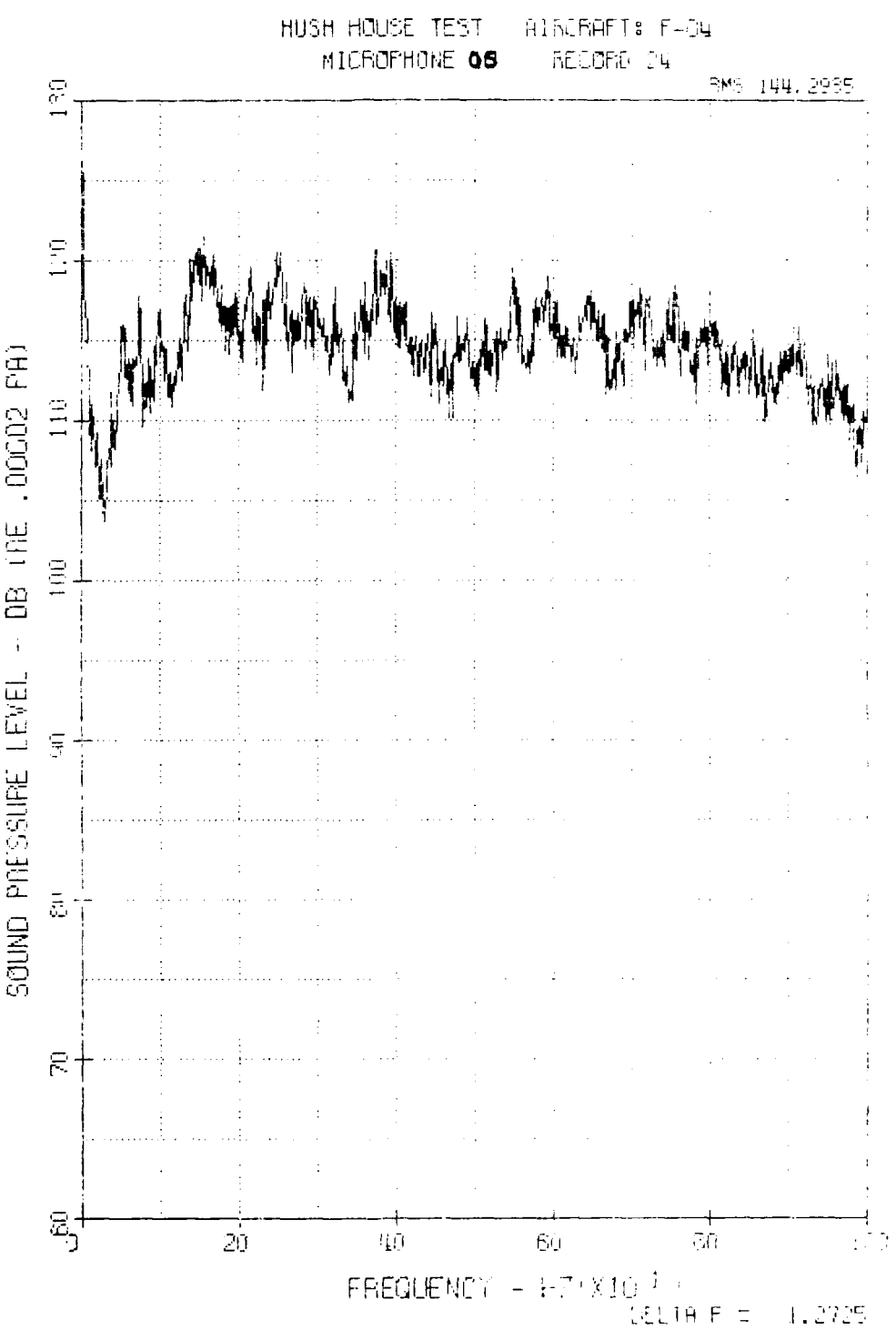
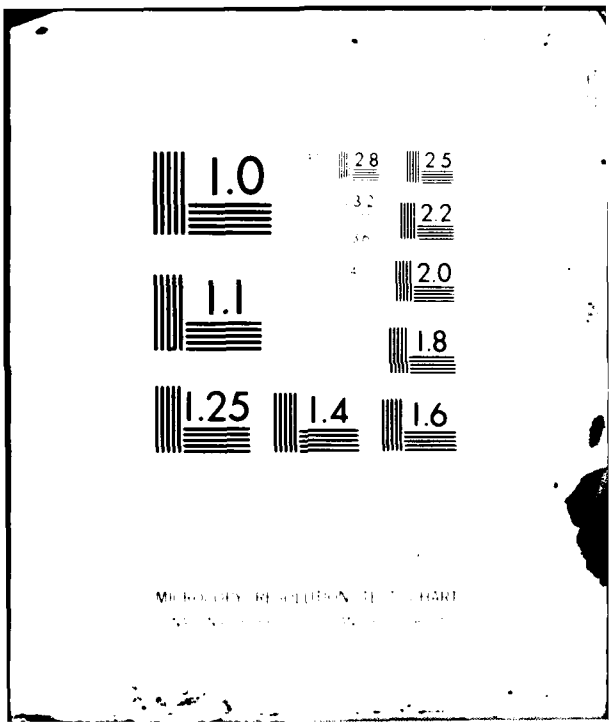


FIGURE B45 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 24 - Microphone 5.

AD-A109 827 AIR FORCE WRIGHT AERONAUTICAL LABS WRIGHT-PATTERSON AFB OH F/G 20/1
ACOUSTIC MEASUREMENTS OF F-4E AIRCRAFT OPERATING IN HUSH HOUSE,--ETC(U)
SEP 81 V R MILLER, G A PLZAK, J M CHINN
UNCLASSIFIED AFWAL-TM-81-84-FIBE/FIBG NL


1.0
2.8
2.5
3.2
2.2
2.0
1.1
1.8
1.25
1.4
1.6

18
43

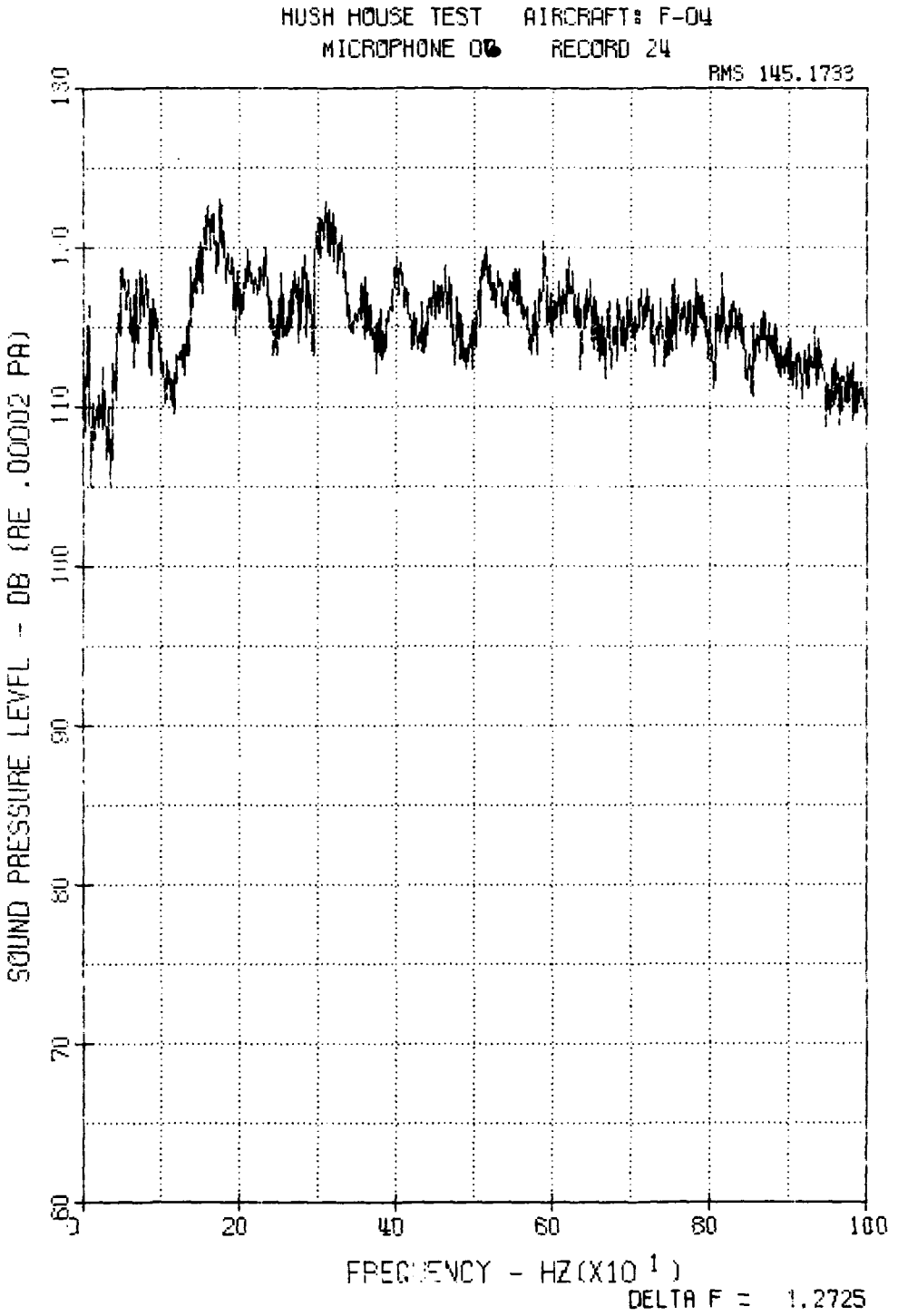


FIGURE B46 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 24 - Microphone 6.

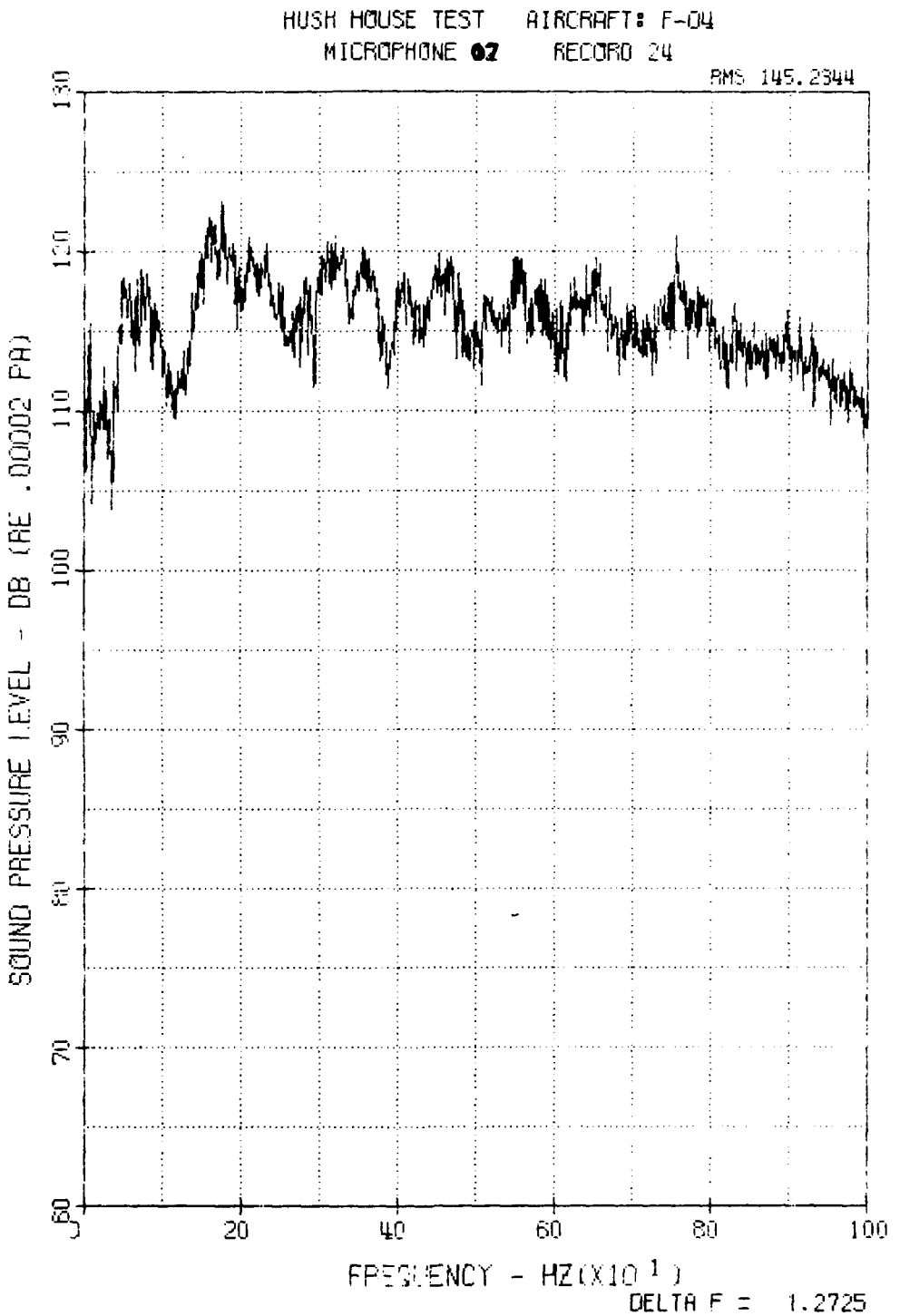


FIGURE B47 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 24 - Microphone 7.

28
49

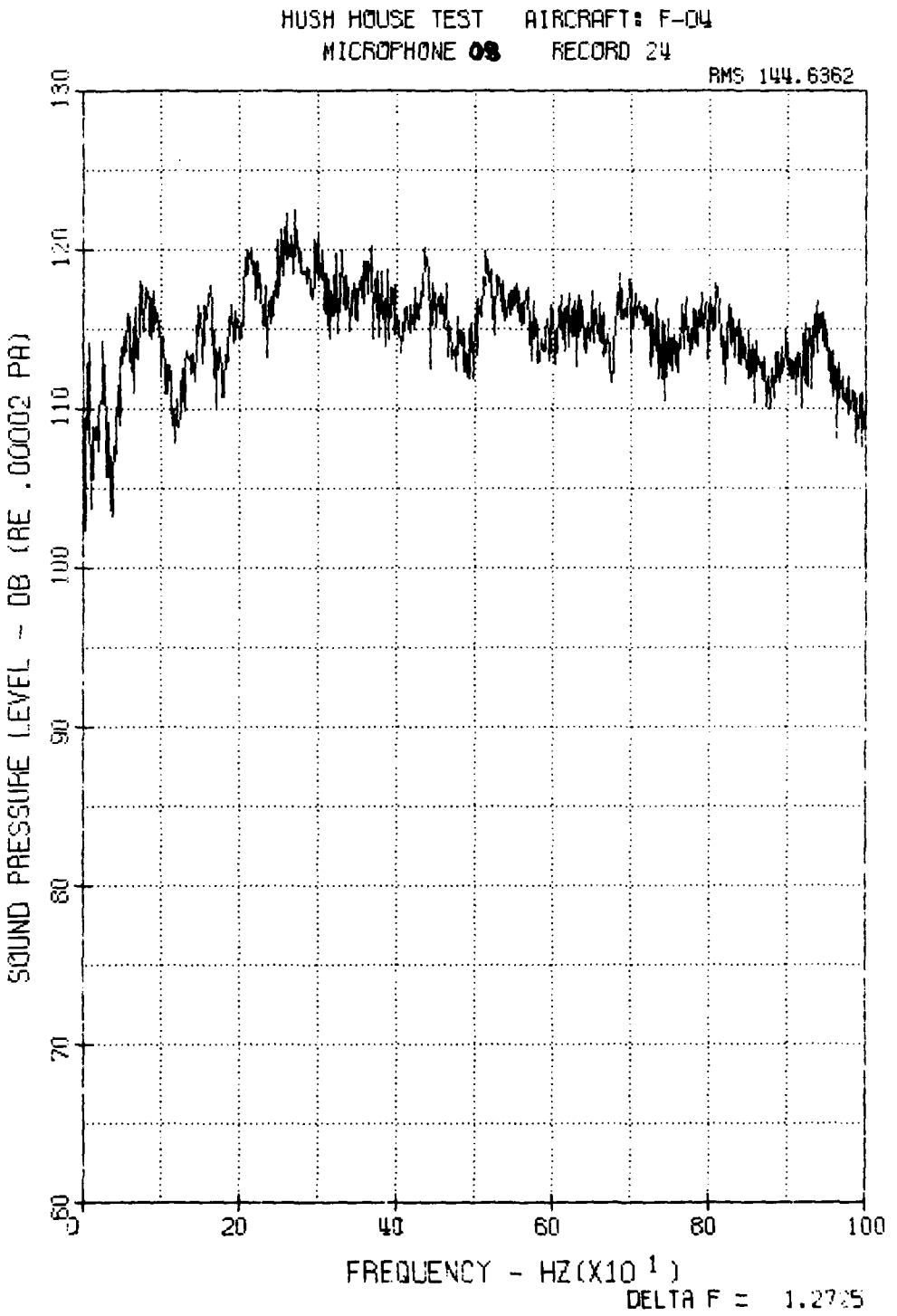


FIGURE B48 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 24 - Microphone 8.

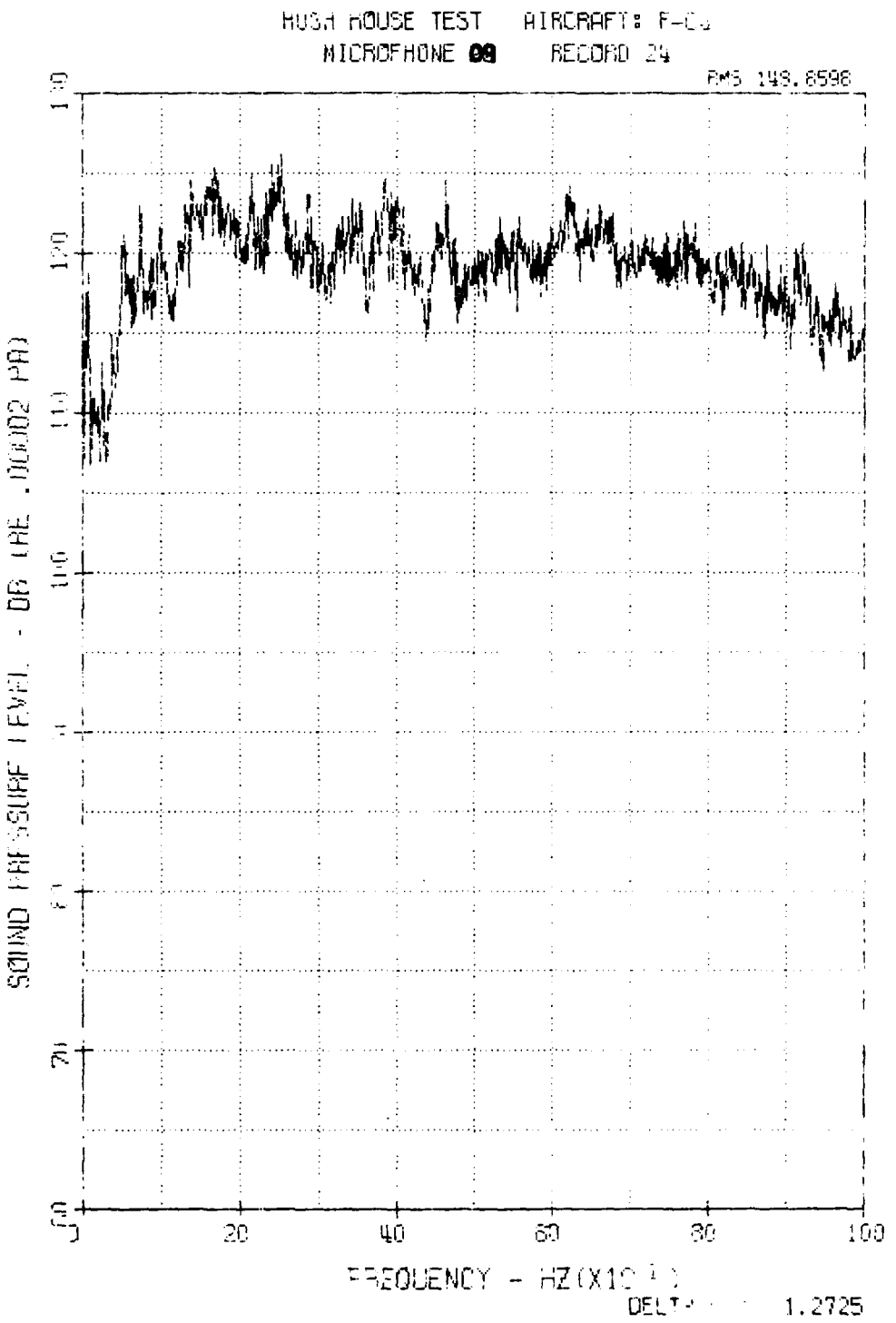


FIGURE B49 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 24 - Microphone 9.

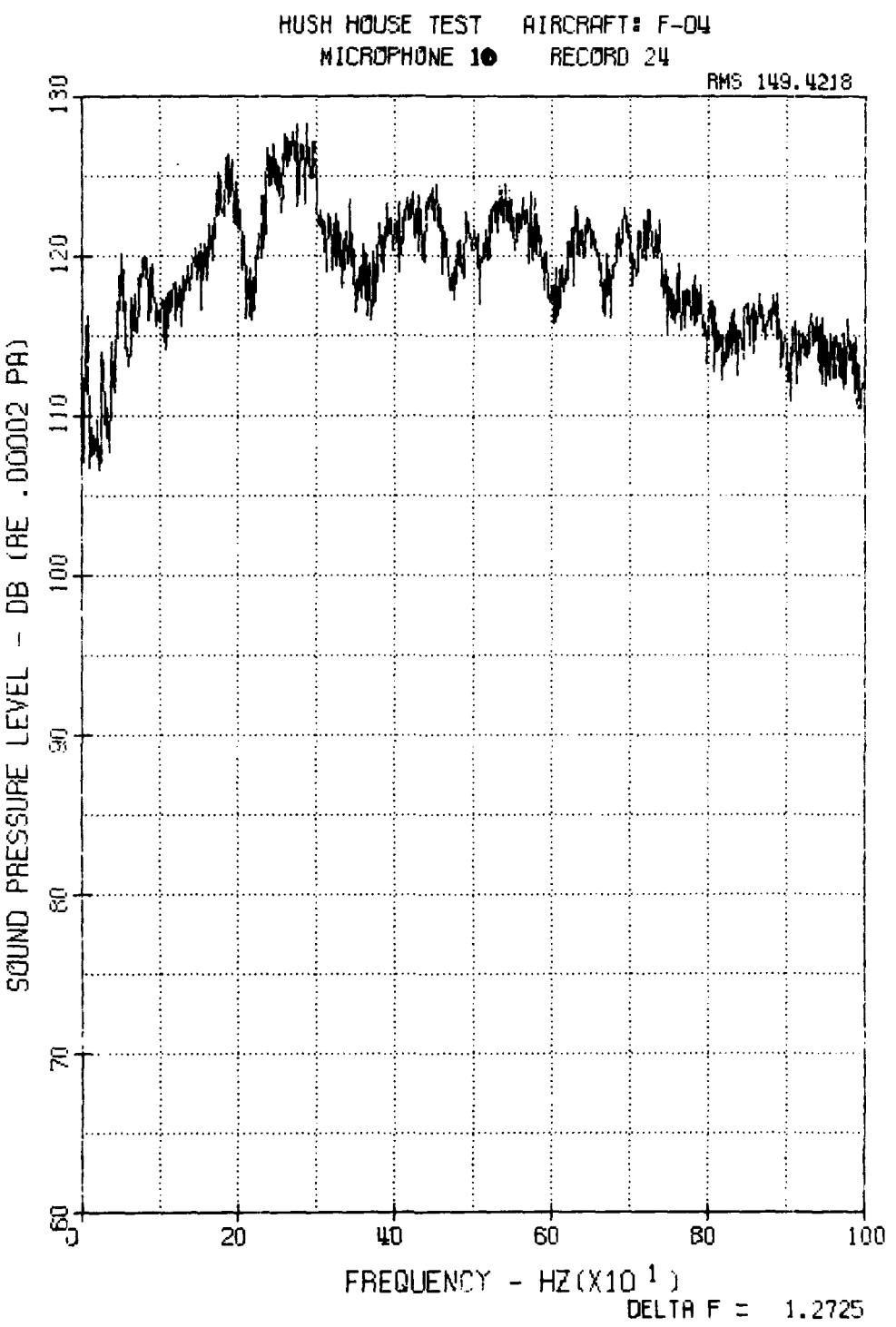


FIGURE B50 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 24 - Microphone 10.

16
36

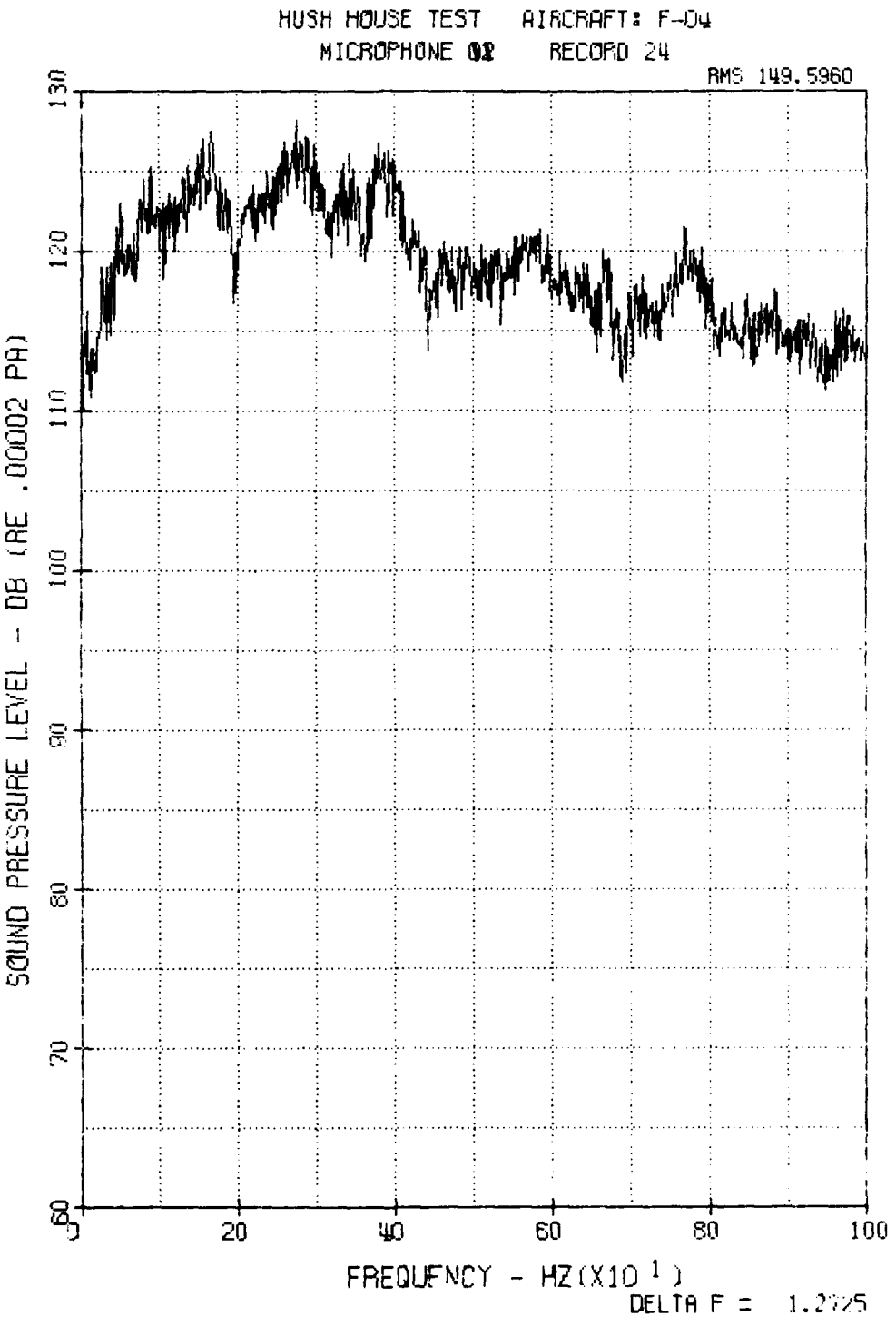


FIGURE B51 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 24 - Microphone 11.

17
2

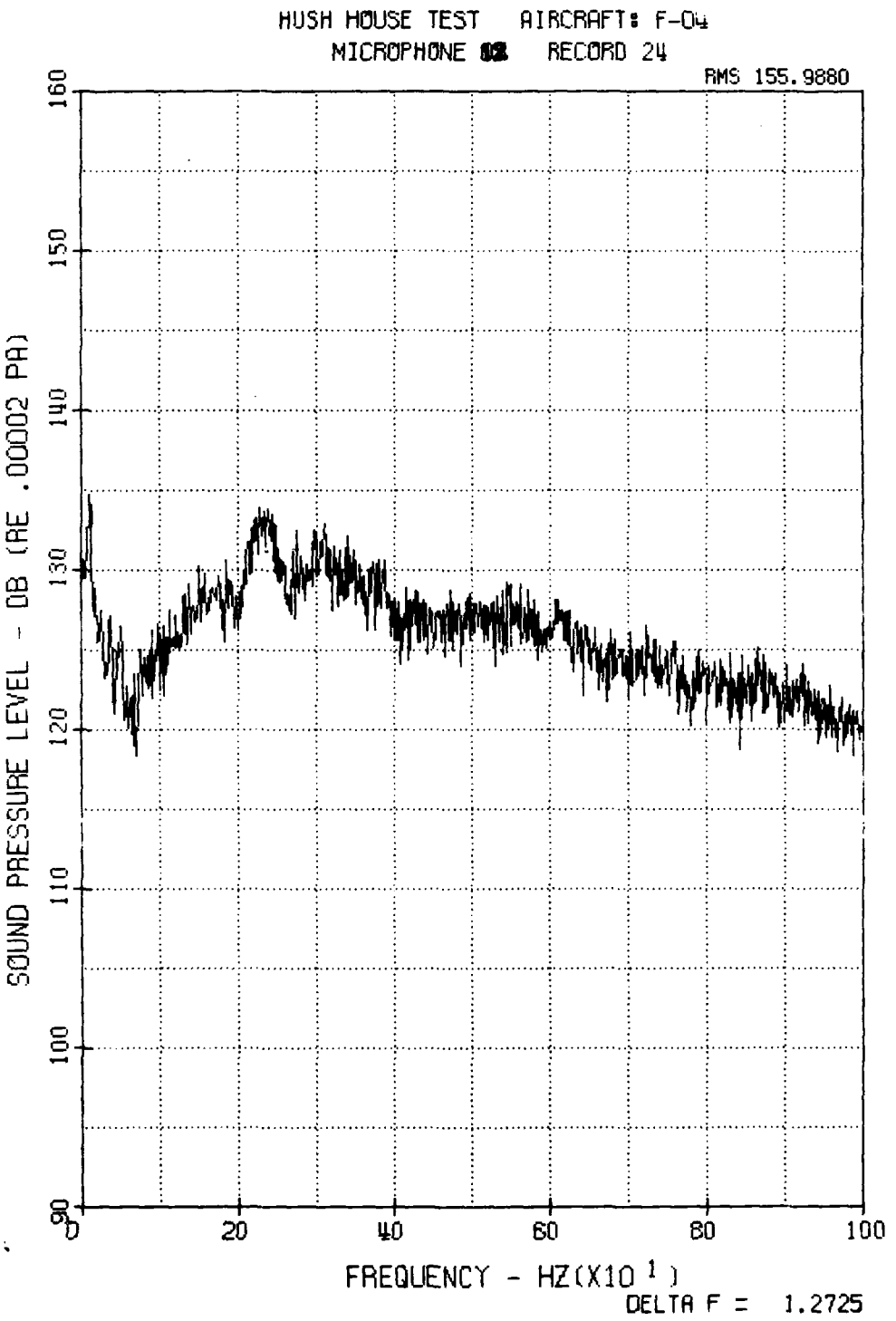


FIGURE B52 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 24 - Microphone 12.

17
1

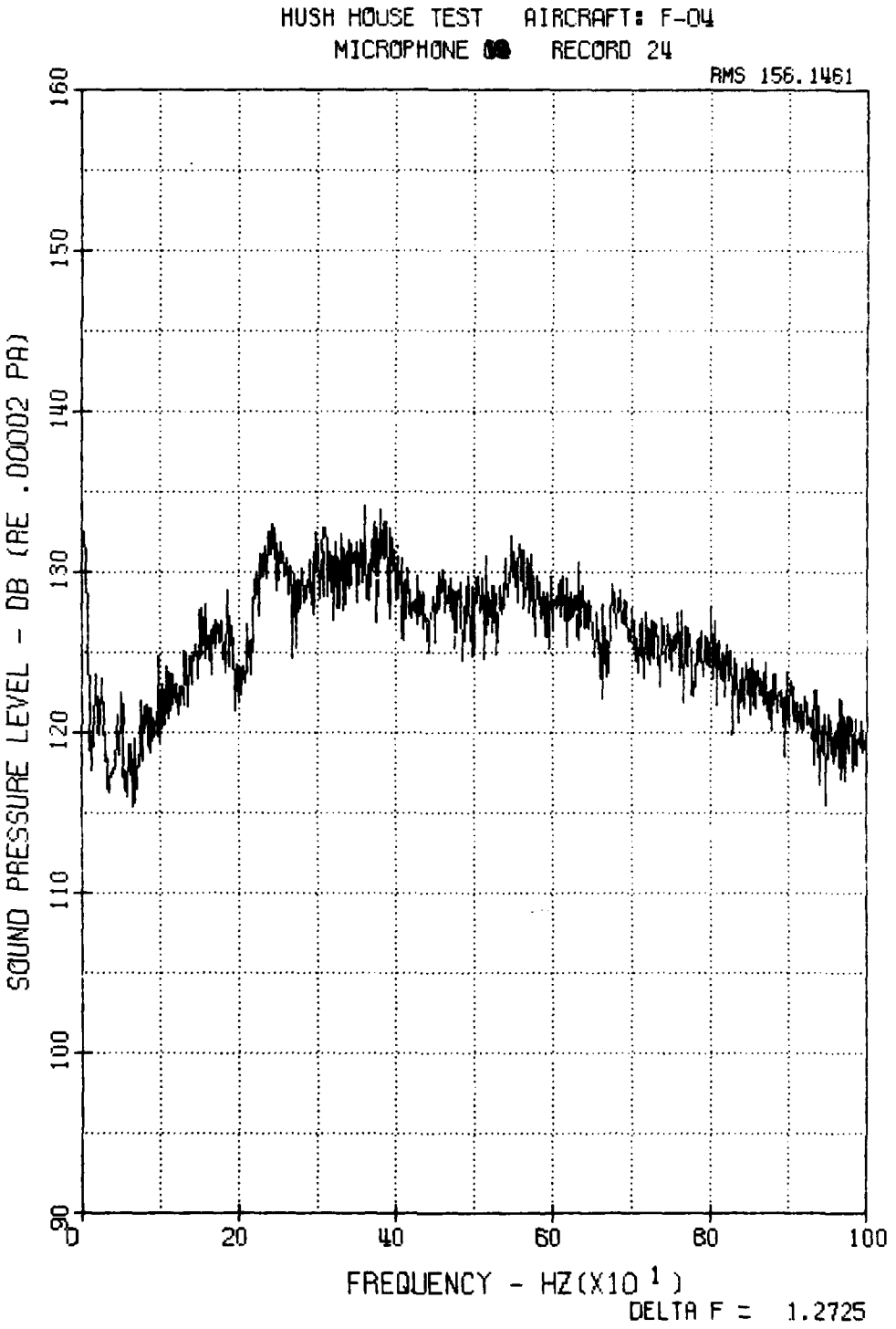


FIGURE B53 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 24 - Microphone 13.

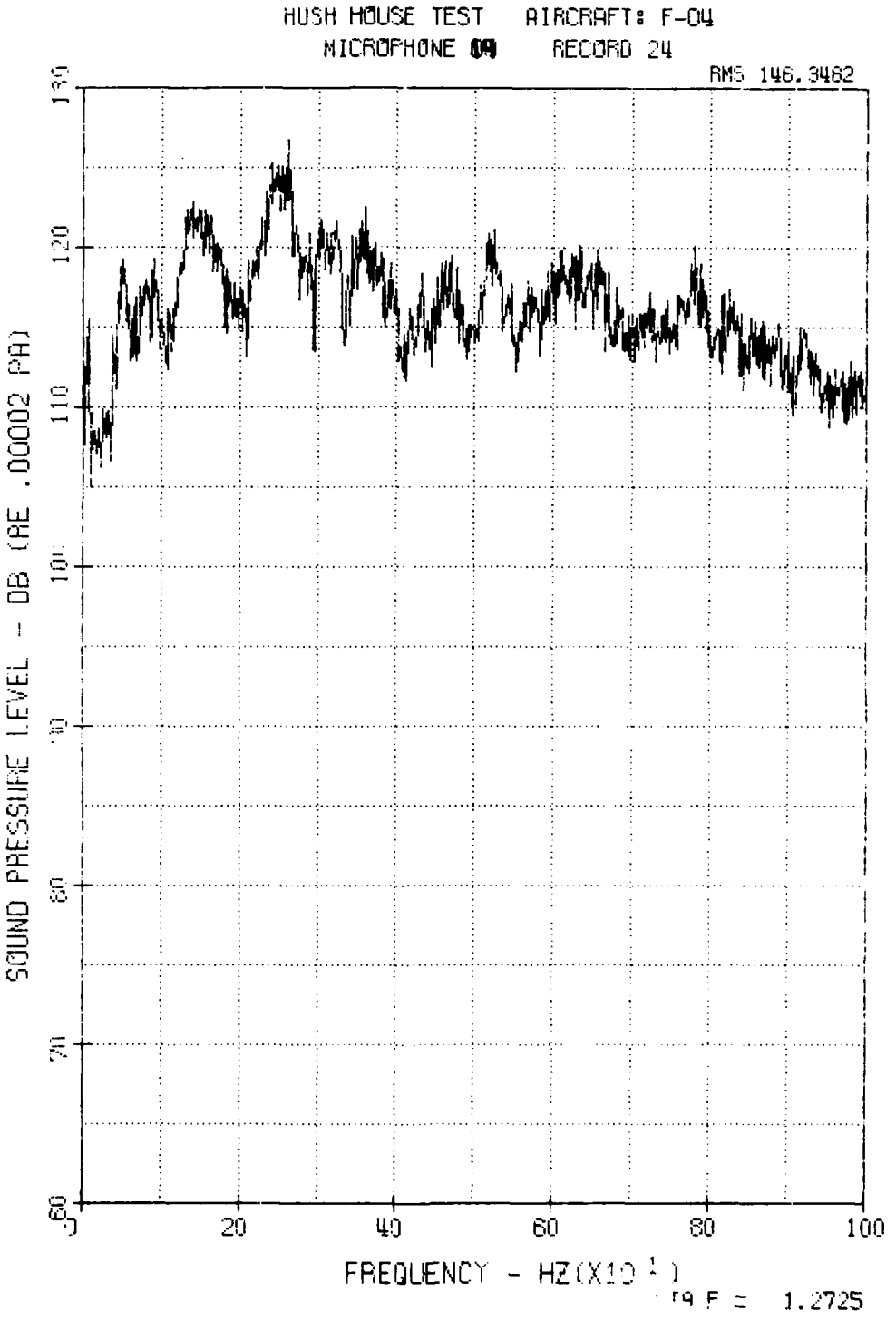


FIGURE B54 Narrowband (1.27 Hz) Spectra for F-4E Aircraft Installed in Hush House for Record Number 24 - Microphone 14.

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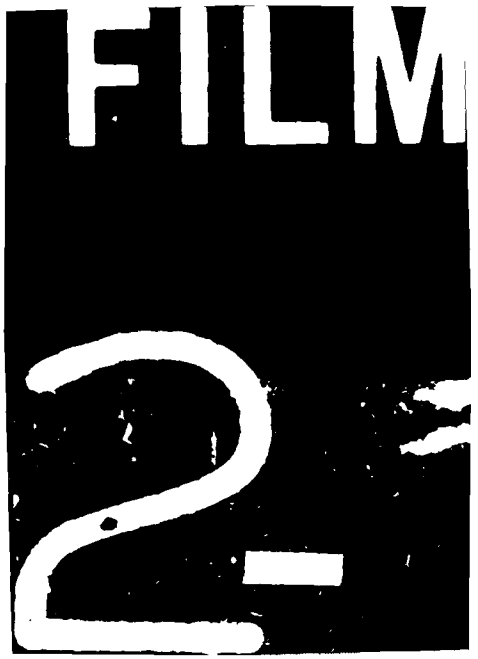
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